Analysis of Reference Design for Nuclear-Assisted Hydrogen Production at 750°C Reactor Outlet Temperature

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May 2010



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High Temperature Electrolysis

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ABSTRACT

The use of High Temperature Electrolysis (HTE) for the efficient production of hydrogen without the greenhouse gas emissions associated with conventional fossil-fuel hydrogen production techniques has been under investigation at the Idaho National Engineering Laboratory (INL) for the last several years. The activities at the INL have included the development, testing and analysis of large numbers of solid oxide electrolysis cells, and the analyses of potential plant designs for large scale production of hydrogen using a hightemperature gas-cooled reactor (HTGR) to provide the process heat and electricity to drive the electrolysis process. The results of this research led to the selection in 2009 of HTE as the preferred concept in the U.S. Department of Energy (DOE) hydrogen technology downselection process. However, the down-selection process, along with continued technical assessments at the INL, has resulted in a number of proposed modifications and refinements to improve the original INL reference HTE design. These modifications include changes in plant configuration, operating conditions and individual component designs. This report describes the resulting new INL reference design coupled to two alternative HTGR power conversion systems, a Steam Rankine Cycle and a Combined Cycle (a Helium Brayton Cycle with a Steam Rankine Bottoming Cycle). Results of system analyses performed to optimize the design and to determine required plant performance and operating conditions when coupled to the two different power cycles are also presented. A 600 MWt high temperature gas reactor coupled with a Rankine steam power cycle at a thermal efficiency of 44.4% can produce 1.85 kg/s of hydrogen and 14.6 kg/s of oxygen. The same capacity reactor coupled with a combined cycle at a thermal efficiency of 42.5% can produce 1.78 kg/s of hydrogen and 14.0 kg/s of oxygen.

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ACRONYMS



Analysis of Reference Design for Nuclear-Assisted Hydrogen Production at 750°C Reactor Outlet Temperature

1. INTRODUCTION

As part of the ongoing activities at the INL to investigate the potential for large-scale production of hydrogen using the nuclear-driven High-Temperature Electrolysis (HTE) process, the INL has evaluated a number of alternative power cycle concepts coupled in different ways to alternative HTE process loop designs. This evaluation process led to the development in 2006 of a preliminary design for a HTGR direct Brayton power cycle coupled to an HTE hydrogen production plant that was designated as the original INL reference HTE design [1]. The HTGR utilized helium at a reactor outlet temperature of 900°C to provide electricity and hightemperature process heat for the electrolytic hydrogen production process. This initial reference design underwent extensive analyses and reviews to refine and optimize the concept. In addition, economic analyses were performed to determine the approximate cost for the commercial production of hydrogen at large scales [2]. The results of these studies, along with the testing and analyses of large numbers of solid oxide electrolysis cells, led to the selection in 2009 of HTE as the preferred concept in the U.S. Department of Energy hydrogen technology down-selection process [3]. However, these evaluations also led to a reconsideration of the reference design and the development of a new INL reference design that would address concerns or issues identified in the original design. These issues included potential materials problems associated with the relatively high reactor outlet temperature of 900°C, the technology development risks associated with the use of a high-temperature helium direct Brayton cycle, and the potential for tritium contamination of the hydrogen production process loop when process heat was transferred directly from the reactor primary loop to the hydrogen production process without an intermediate loop to provide additional separation between the reactor and hydrogen production loops.

To address these issues, a new INL reference design has been developed and evaluated using the HYSYS process analysis software. Initial HYSYS evaluations were also performed for two nuclear-driven power cycle concepts intended for the production of the electricity and process heat required by the INL reference HTE hydrogen production process. The optimized power cycle designs were then coupled to the new INL reference HTE hydrogen production process, and the HYSYS models of the integrated systems were optimized to maximize the total hydrogen production rates and overall hydrogen production efficiencies for the two integrated power cycle/INL reference hydrogen production concepts. This analysis process, along with the resulting optimized reference designs for the two integrated nuclear-driven hydrogen production plant concepts are discussed in the following sections of this report.

2. SELECTION OF POWER CYCLES

Two power cycles, a Steam Rankine Cycle and a Combined Cycle (an Indirect Helium Brayton Cycle with a Steam Rankine Bottoming Cycle), were evaluated as part of the development of the new INL Reference HTE hydrogen production process. These two power cycles were assumed to be powered by an HTGR whose configuration and operating conditions are based on the latest design parameters planned for the Next Generation Nuclear Plant

(NGNP). The current HTGR reference design specifies a reactor power of 600 MW_t, with a primary system pressure of 7.0 MPa, and reactor inlet and outlet fluid temperatures of 322°C and 750°C, respectively. Assuming the same reactor operating conditions, each of these power cycles was separately optimized, using the HYSYS process analysis software to maximize power cycle efficiency prior to coupling the power cycles to the new INL Reference HTE hydrogen production process. The following two sections describe the optimized power cycle designs, and Section 3 of this report describes the two integrated power cycle/HTE hydrogen production concepts optimized to maximize hydrogen production rates and overall hydrogen production efficiencies.

For this analysis the following assumptions were made:

- The minimum approach temperature for most of the heat exchangers is 25°C. This approximates heat exchangers with efficiencies near 95%.
- The high temperature recuperating heat exchangers in the high temperature electrolysis process have minimum approach temperatures of 20°C because they have relatively smaller temperature differences between the inlet and outlet conditions
- The primary and secondary helium loops and the HTE loop have heat exchanger pressure drops equal to 2% of the average pressure in the loops.
- The power cycles have 2% pressures drops based on inlet pressures except for the steam generator and the reheater of the Rankine cycle which have a 10% pressure drop.
- The primary and secondary circulators and the Brayton cycle turbines and compressors have adiabatic efficiencies of 90%
- The hydrogen recirculator and all pumps have adiabatic efficiencies of 75%
- The Rankine high pressure turbine, intermediate pressure turbine and low pressure turbine have adiabatic efficiencies of 85%, 90%, and 80%.

2.1 Steam Rankine cycle

The first power cycle evaluated for the new INL Reference Design was a Steam Rankine Cycle. This Steam Rankine cycle, shown in Figure 1, is powered by a 600 MW $_t$ helium-cooled HTGR operating at a primary system pressure of 7.0 MPa, and reactor inlet and outlet fluid temperatures of 322°C and 750°C, respectively. As shown in Figure 1, hot helium from the reactor outlet at 750°C (Stream 2) is split (T13) with 77% of the flow transferring heat to the Rankine Cycle steam generator, and the remaining 23% of the flow transferring heat to the Rankine Cycle reheater.

The Rankine Cycle flow sheet in Figure 1 includes three turbines; a High Pressure Turbine, a two stage Intermediate Pressure Turbine, and a five stage Low Pressure Turbine. The steam generator delivers steam at approximately 593°C and 24MPa to the inlet of the High Pressure Turbine. To maximize the thermodynamic efficiency of the cycle, most of the steam exiting the High Pressure Turbine is passed through the reheater before entering the first stage of the

Intermediate Pressure Turbine. Between each stage of expansion, a portion of the steam flow is used to supply heat to seven feedwater heaters. One of these feedwater heaters (between Stages 1 and 2 of the Low Pressure Turbine) is an open heater that exchanges its heat by mixing, allowing for deaeration of the working fluid. A condenser is used to reject the remaining waste heat from the Stage 5 low pressure turbine exhaust. The feedwater is then returned to the steam generator inlet utilizing a condensate pump, booster pump, and boiler feed pump to recover pressure at various points in the feedwater return. Pressure control valves are also included in the process flow model to ensure appropriate operating conditions at each of the feedwater heaters locations.

The optimized power cycle efficiency for this configuration is 44.4%. The efficiency was calculated by summing the power generated by the turbines and subtracting the power from the pumps, the power needed to cool the condenser, and the fraction of the power of the primary loop circulator used for power production and dividing that total by the fraction of the reactor heat used for power production. The power to cool the condenser was calculated using a procedure found in reference 5.

The HYSYS calculated fluid conditions, flow rates, and component operating parameters for the Steam Rankine Cycle shown in Figure 1, are provided in Appendix A.

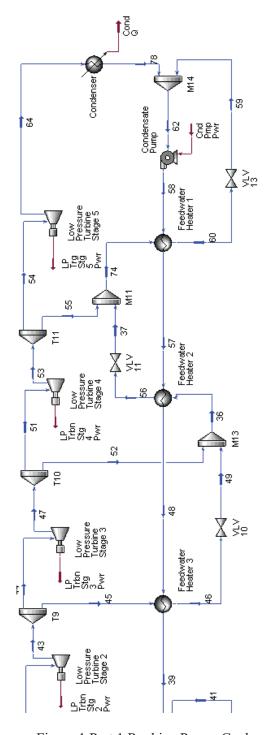


Figure 1 Part 1 Rankine Power Cycle

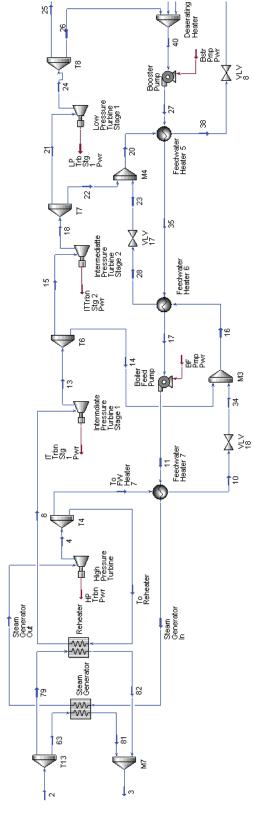


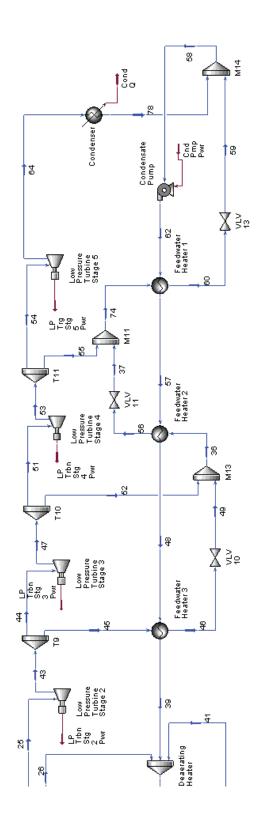
Figure 1 (Part 2) Rankine Power Cycle

2.2 Combined Indirect Helium Brayton and Steam Rankine Cycles

The second power cycle evaluated for the new INL Reference Design is an indirect helium recuperated Brayton cycle combined with a Steam Rankine bottoming cycle. The HYSYS model for this cycle, shown in Figure 2, again assumed a 600 MW_t, HTGR operating at a primary system pressure of 7.0 MPa and reactor inlet and outlet fluid temperatures of 322°C and 750°C, respectively.

Helium from the reactor outlet is split into two streams at "TEE-100" and transfers heat via two helium-to-helium heat exchangers to the secondary helium power conversion loop which is also operating at a maximum pressure of 7.0 MPa. The indirect helium recuperated Brayton cycle shown at the top of the process flow sheet consists of a High Pressure Turbine (HP Turbine) and a Low Pressure Turbine (HP Turbine). Heat transferred from the primary system at HX 1 raises the secondary helium temperature at the High Pressure Turbine inlet to 725°C at a secondary system pressure of 7 MPa. The secondary helium then flows through the high pressure turbine where the gas is expanded to produce approximately 98.8 MW of electric power. The secondary helium, at a reduced pressure (4.35 MPa) and temperature (570°C), then passes through the second helium-to-helium heat exchanger (IHX 2), where heat from the primary system fluid raises the secondary helium temperature back to 725°C before entering the Low Pressure Turbine (LP Turbine). The secondary helium expands through the Low Pressure Turbine producing approximately 96.4 MW of additional electric power. The secondary helium leaving the Low Pressure Turbine at 573°C and 2.68 MPa then passes through a recuperator and precooler where it is further cooled before entering the low-pressure compressor. To improve compression efficiencies, the helium is again cooled in an intercooler heat exchanger before entering the high-pressure compressor. The helium exits the high-pressure compressor at a pressure of approximately 7.3 MPa. The coolant then circulates back through the recuperator where the recovered heat raises its temperature to the inlet temperature of the IHX 1 heat exchanger, completing the secondary helium loop circuit. The primary helium flows leaving the IHX 1 and IHX2 heat exchangers recombine at MIX-100 and the total flow is delivered to the Steam Rankine bottoming cycle interface (T13) at a temperature and pressure of approximately 684°C and 6.9 MPa, respectively. Here the flow is again split with 78% of the flow going to the Rankine Cycle steam generator and the remaining flow going to the Rankine Cycle reheater.

The Steam Rankine Cycle shown at the bottom of the process flow sheet in Figure 2 is identical to that shown in Figure 1. The Rankine Cycle efficiency in this configuration is not as efficient because of the lower operating temperatures when operating in a bottoming cycle configuration, The resulting optimized Combined Cycle efficiency for the configuration shown in Figure 2 is 42.5%.



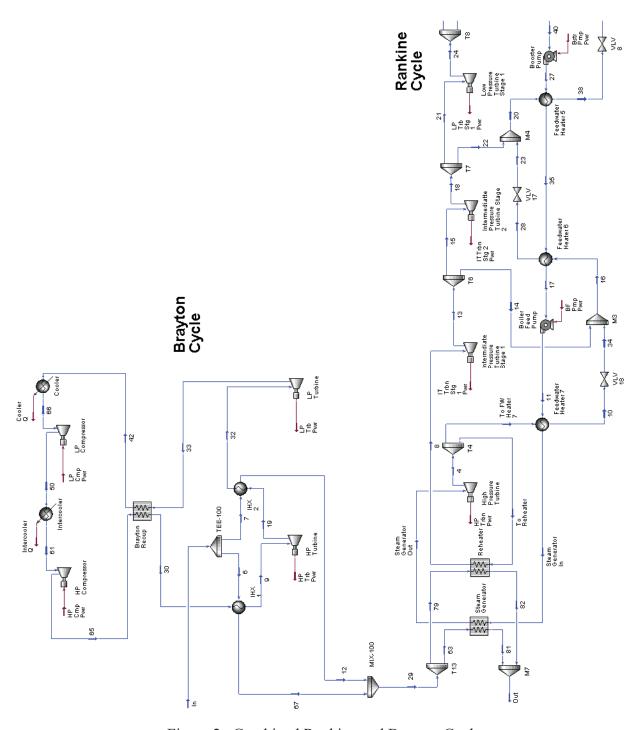


Figure 2. Combined Rankine and Brayton Cycle

3. DESCRIPTION OF REFERENCE HTE PROCESS

An INL reference design for HTE hydrogen production process was developed, and optimized for both the Steam Rankine and Combined power cycles described above. The HYSYS model of the reference HTE hydrogen production process coupled to the Rankine Steam

cycle is shown in Figure 3. Since the process flow sheet of the reference HTE process is the same for both the Steam Rankine and Combined cycles, the system description of the HTE process coupled to the Steam Rankine power cycle (shown in Figure 3 and described here) also apply to the coupling of the reference HTE process to the Combined power cycle. However, because of differences in power cycle efficiency, the resulting hydrogen production rates and overall hydrogen production efficiencies will be different for the two integrated power cycle/HTE processes, as discussed in the Analysis Results Section of this report.

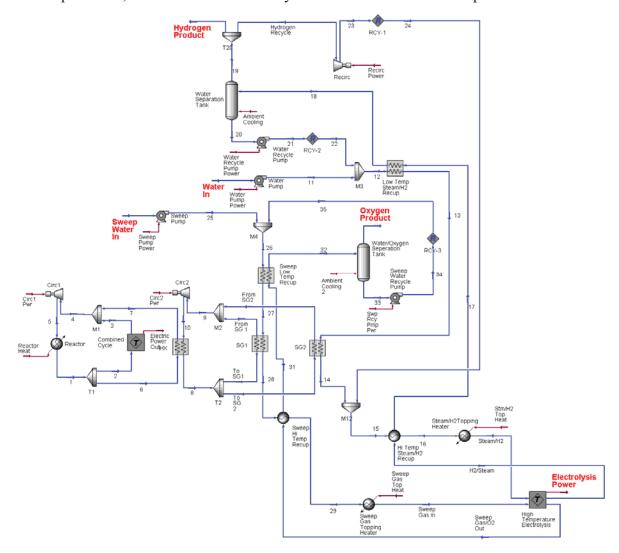


Figure 3. HYSYS process flow diagram of reference HTE hydrogen production process.

The optimized reference design for the HTE hydrogen production process shown in Figure 3 operates at a system pressure of 5 MPa and uses a steam sweep system rather than the air sweep system used in the original INL reference design to remove oxygen from the anode side of the electrolyzer. This change was made from the original reference design so that the oxygen product gas, which represents a valuable commodity, can be recovered by condensing the steam and recovering the dry oxygen product gas for later sale.

The HTGR (depicted on the left side of the process flow sheet in Figure 3) provides both electricity and process heat to drive the HTE process. The power conversion system used to produce electricity to drive the electrolysis process is modeled in a sub-flow sheet designated by the letter "T" on the left side of the process flow sheet in Figure 3. The sub-flow sheet models are depicted in Figure 1 for the Rankine cycle and Figure 2 for the Combined cycle. In both cases, an AC to DC power conversion efficiency of 96% was assumed for supplying DC power to the electrolyzer.

Process heat from the HTGR (which represents only about 10% of the total reactor power) is transferred from the primary loop through an intermediate heat exchanger (IHX) to an intermediate helium loop, and then to the two steam generators (SG1 and SG2) shown in Figure 3. The use of the intermediate loop between the reactor primary system and the HTE process was included in the new INL reference design as an added barrier to minimize the potential for tritium migration from the primary system, and potential tritium contamination of the HTE product hydrogen.

Feed water for the HTE process (Water In) is raised to the system operating pressure of 5 MPa by a pump, where it is then mixed with recycled water condensed from the hydrogen product water separation tank. The water stream is then partially vaporized in the recuperator (Low Temp Steam/H2 Recup) which recovers heat from the post-electrolysis process. The low quality feed stream then enters a steam generator (SG1) where the remaining water is vaporized and the steam is heated to approximately 100°C below the electrolysis operating temperature of 800 °C. Downstream of the recuperator, at M2, the steam is mixed with recycled hydrogen product gas. A fraction of the product gas is recycled in this way in order to assure that reducing conditions are maintained on the steam/hydrogen electrode. The resulting steam and hydrogen mixture (approximately 10% hydrogen) then passes through a second post-electrolysis process recuperator and a gas-fired or electric heater to raise its temperature to the desired electrolysis operating temperature of 800 °C.

The process stream then enters the electrolyzer, where oxygen is electrolytically removed from the steam, producing hydrogen and oxygen. The custom electrolyser module developed at INL for direct incorporation into the HYSYS process analysis code is described in more detail in the following section.

Downstream of the electrolyzer, the hydrogen-rich product stream (approximately 70 mol % hydrogen) passes back through the two post-electrolysis recuperators where the product stream is cooled and, as described earlier, the recovered heat is used to heat the inlet process stream to near the desired electrolysis process temperature. The product stream is then further cooled at the Water Separation Tank, where the majority of any residual steam is condensed and separated, yielding the dry hydrogen product. The cooled product stream is split at T2 and a fraction of the product gas is recycled into the inlet process stream as discussed previously. A recirculating blower is required to repressurize the hydrogen recycle stream to the upstream pressure at M2.

As mentioned earlier, the new INL reference design uses a steam sweep system to remove the excess oxygen that is evolved on the anode side of the electrolyzer. In the steam sweep system, the inlet water (Sweep Water In) is raised to the system operating pressure by the Sweep Pump, and then mixed with condensed water recirculated back from the Water/Oxygen separation tank at M4. The recirculation of condensed water from the oxygen product stream significantly reduces the net amount of water needed to operate the steam sweep system. After leaving the M4 mixer, the sweep water passes through a recuperator (Sweep Low Temp Recup), where recovered heat from the sweep system heats and vaporizes most of the feed water. The high quality steam then passes through steam generator SG1, where it is superheated to approximately 100°C below the electrolysis operating temperature of 800°C. The steam then passes through a second sweep system recuperator (Sweep Hi Temp Recup) and a gas fired or electric heater where the sweep steam is raised to 800°C before entering the electrolyzer stack.

After removing the excess oxygen from the anode of the electrolyzer, the steam/oxygen mixture (50% oxygen) then passes through the two previously discussed steam sweep system recuperators, where excess heat is recovered, and the post-electrolysis steam-oxygen mixture is cooled. The resulting high quality steam-oxygen mixture is then further cooled in the Water/Oxygen Separation Tank, where the majority of the water is condensed and recirculated back to be combined with the sweep water feed at M4. The relatively dry oxygen product leaving the Water/Oxygen Separation Tank at high pressure (4.9 MPa) is then available for immediate use or storage for later use.

4. ELECTROLIZER MODEL

The electrolyzer model process flow diagram is shown in Figure 4. The process inlet flow, consisting of steam and hydrogen passes through a conversion reactor where the steam is split into hydrogen and oxygen. The conversion reactor uses a stoichiometric equation for the splitting of water. Based upon the utilization, a specified percentage of the steam is converted. HYSYS calculates the heat of reaction for this conversion, which is shown as the "Electrolysis Heating" energy stream in Figure 4. The hydrogen, oxygen, and steam enter a component splitter labeled Electrodes. The oxygen is split from the other components and exits at the anode stream. The sweep gas mixes with the anode stream and exits as the "Sweep/Gas O2 Out" stream. An embedded spreadsheet is used to calculate the Nernst potential, operating voltage, current and electrolysis power [4]. In this reference case, the boundary conditions are isothermal and adiabatic which is referred as the thermal neutral point.

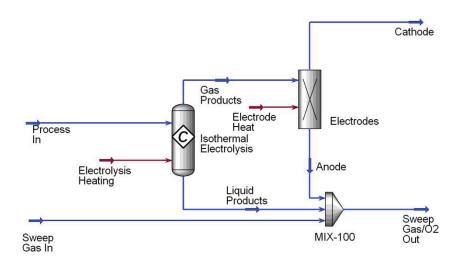


Figure 4. Electrolyzer model process flow diagram.

5. ANALYSIS RESULTS

5.1 HTE process coupled to Steam Rankine cycle

The HYSYS analysis of the above described new INL reference design coupled to the Steam Rankine cycle achieves a hydrogen production rate of 1.85 kg/s and an overall hydrogen production efficiency of 42.8% with a reactor power source of 600 MW_t operating at a reactor outlet temperature of 750 °C. The overall hydrogen production efficiency is the higher heating value of the hydrogen product divided by the total heat input. The total heat input for both cases is the sum of the reactor heat plus the heat needed by the two topping heaters in the HTE loop. The electrolysis stack consists of 1.119 million electrolysis cells operating at a current density of 0.6989 amp/cm², and a steam utilization rate of 66.67%. Each cell has an area of 225 cm². The fluid conditions, flow rates, stream composition and component operating parameters for this integrated configuration are summarized in Tables 1-6 for each of the locations shown in Figure 3. The temperature, pressure, molar and mass flow rates, and the vapor fraction for each stream are displayed in Table 1.

The composition of each stream is shown in Table 2. The thermal duty, overall heat transfer coefficient, UA, log-mean temperature difference, LMTD, and the minimum approach temperature for each heat exchanger is found in Table 3. Compressor and pump parameters are given in Tables 4. Table 5 provides the topping heater heat rates and the electrolysis power corresponding to the variables shown in Figure 3. Heater data are provided in Table 6.

Table 1. Stream properties of Rankine case.

Stream Name	Vapor	Temperature	Pressure	Molar Flow	Mass Flow
	Fraction	(C)	(MPa)	(kgmole/h)	(kg/s)
1	1	750	7	67.474	270.1
2 _	1	750	7	60.446	241.97
3	1	311.02	6.86	60.446	241.97
4	1	314.05	6.86	67.474	270.1
5	1	322	7.071	67.474	270.1
6	1	750	7	7.0275	28.131
_ 7	1	340.11	6.86	7.0275	28.131
	1	725	7	7.03	28.141
9	1	304.76	6.86	7.03	28.141
10	1	315.11	7.14	7.03	28.141
11	0	27.317	5.4	0.9144	16.473
12	0	26.897	5.4	1.3679	24.643
13	0.2712	268.86	5.3	1.3679	24.643
14	1	700	5.2	1.3679	24.643
15	1	650.93	5.2	1.52	24.951
16	1	756.9	5.1	1.52	24.951
17	1	670.93	4.9	1.52	10.36
18	0.7725	144.05	4.8	1.52	10.36
19	1	26	4.8	1.0649	2.1614
	0	26	4.8	0.45512	8.1986
21	0	26.052	5.4	0.45512	8.1986
22	0	26.052	5.4	0.45351	8.1697
23	1	35.491	5.2	0.15254	0.30961
24	1	35.491	5.2	0.15211	0.30873
	0	27.317	5.4	5.01E-04	9.03E-03
26	0	27.053	5.4	0.45611	8.2178
27	1	346.69	5.3	0.45611	8.2178
28	1	700	5.2	0.45611	8.2178
29	1	780	5.1	0.45611	8.2178
30	1	755.74	4.9	0.91209	22.809
31	0.8172	203.63	4.8	0.91209	22.809
32	0	27	4.8	0.45561	8.2087
33	0	27.052	5.4	0.45561	8.2087
_	0 1	27.052	5.4 6.86	0.45561 6.0955	8.2088 24.4
From SG2 From SG 1	1	293.92 375.42	6.86	0.93455	3.741
H2/Steam	1	800	5.80	1.52	10.36
Hydrogen Product	1	26	4.8	0.91236	1.8518
Hydrogen Product Hydrogen Recycle	1	26	4.8	0.91236	0.30961
Oxygen Product	1	27	4.8	0.15254	14.6
Steam/H2	1	800	4.8	1.52	24.951
Sweep Gas In	1	800	5	0.45611	8.2178
Sweep Gas in	1	800	5	0.43011	0.21/8

Stream Name	Vapor	Temperature	Pressure	Molar Flow	Mass Flow
	Fraction	(C)	(MPa)	(kgmole/h)	(kg/s)
Sweep Gas/O2 Out	1	800	5	0.91209	22.809
Sweep Water In	0	26.85	0.10132	5.01E-04	9.03E-03
To SG1	1	725	7	0.93455	3.741
To SG 2	1	725	7	6.0955	24.4
Water In	0	26.85	0.10132	0.9144	16.473

Table 2. Stream composition of Rankine case.

Stream Name	Comp	Comp	Comp	Comp
	Mole	Mole	Mole	Mole
	Frac	Frac	Frac	Frac
	(H ₂)	(H₂O)	(O ₂)	(He)
1	0	0	0	1
2	0	0	0	1
3	0	0	0	1
4	0	0	0	1
5	0	0	0	1
6	0	0	0	1
7	0	0	0	1
8	0	0	0	1
_ 9 _	0	0	0	1
10	0	0	0	1
11	0	1	0	0
12	0.00002	0.99998	0	0
13	0.00002	0.99998	0	0
14	0.00002	0.99998	0	0
_ 15 _	0.1	0.9	0	0
16	0.1	0.9	0	0
17	0.7	0.3	0	0
18	0.7	0.3	0	0
19 	0.99914	0.00086	0	0
_ 20 _ 21	0.00005	0.99995	0	0
_ 21 22	0.00005 0.00005	0.99995 0.99995	0	0 0
	0.00003	0.99995	0	0
25 	0.99914	0.00086	0	0
24 	0.99914	0.00086	0	0
_ 25	0	0.99986	0.00014	0
	0	0.99986	0.00014	0
_	0	0.99986	0.00014	0
20 29	0	0.99986	0.00014	0
30	0	0.50001	0.49999	0
_ 30 _ 31	0	0.50001	0.49999	0

Stream Name	Comp Mole Frac (H ₂)	Comp Mole Frac (H ₂ O)	Comp Mole Frac (O ₂)	Comp Mole Frac (He)
32	0	0.99986	0.00014	0
33	0	0.99986	0.00014	0
34	0	0.99986	0.00014	0
From SG2	0	0	0	1
From SG 1	0	0	0	1
H2/Steam	0.7	0.3	0	0
Hydrogen				
Product	0.99914	0.00086	0	0
Hydrogen				
Recycle	0.99914	0.00086	0	0
Oxygen				
Product	0	0.0011	0.9989	0
Steam/H2	0.1	0.9	0	0
Sweep Gas In	0	0.99986	0.00014	0
Sweep Gas/O2				
Out	0	0.50001	0.49999	0
Sweep Water				
In	0	1	0	0
To SG1	0	0	0	1
To SG 2	0	0	0	1
Water In	0	1	0	0

Table 3. Heat exchanger data for Rankine case.

Name	Duty (kW)	UA (kJ/C-h)	LMTD (C)	MinimumApproach (C)
Sweep Hi Temp Recup	1,570	45,100	35	20
Hi Temp Steam/H2 Recup	6,668	221,100	30	20
Low Temp Steam/H2 Recup	39,010	447,600	87	25
_SG1	6,790	253,700	27	25
SG2	54,600	544,000	100	25
Sweep Low Temp Recup	24,410	257,500	95	25
IHX	59,860	2,395,000	25	25

Table 4. Pump data.

Name	Water	Water	Sweep	Sweep Water
	Pump	Recycle	Pump	Recycle Pump
		Pump		
Delta P (MPa)	5.299	0.6	5.299	0.6
Energy (kW)	115.7	6.507	6.34E-02	6.52
Feed Pressure (MPa)	0.1013	4.8	0.1013	4.8
Product Pressure (MPa)	5.4	5.4	5.4	5.4
Molar Flow (kgmole/h)	0.9144	0.4551	5.01E-04	0.4556
Adiabatic Efficiency (%)	75	75	75	75

Table 5. Circulator data for Rankine case.

Name	Recirc	Circ1	Circ2
Feed Pressure (MPa)	4.8	6.86	6.86
Product Pressure (MPa)	5.2	7.071	7.14
Molar Flow (kgmole/s)	0.1525	67.47	7.03
Energy (kW)	42	11280	1531
Adiabatic Efficiency	75	90	90
Polytropic Efficiency	75	90	90

Table 6. Heater data for Rankine case

Name	Steam/H2Topping Heater	Sweep Gas Topping Heater	Reactor	Electrolysis Unit
Duty (kW)	2,752	399	600,000	
Power (kW)				226,354
Feed Temperature (C)	757	780	322	800
Product Temperature (C)	800	800	750	800

5.2 HTE process coupled to Combined cycle

The HYSYS analysis of the new INL reference design coupled to the Combined cycle (Indirect Helium Brayton with Steam Rankine Bottoming Cycle) achieves a hydrogen production rate of 1.78 kg/s and an overall hydrogen production efficiency of 41.0% with a reactor power source of 600 MW $_{\rm t}$ operating at a reactor outlet temperature of 750 °C. The electrolysis stack consists of 1.073 million electrolysis cells operating at a current density of 0.6989 amp/cm 2 , and a steam utilization rate of 66.67%. Each cell has an area of 225 cm 2 . The fluid conditions, flow rates, stream composition and component operating parameters for this integrated configuration are summarized in Tables 7-12 for each of the locations shown in Figure 3. The temperature, pressure, molar and mass flow rates, and the vapor fraction for each stream are displayed in Table 7.

The composition of each stream is shown in Table 8. The thermal duty, overall heat transfer coefficient, UA, log-mean temperature difference, LMTD, and the minimum approach temperature for each heat exchanger is found in Table 9. Compressor and pump parameters are given in Tables 10. Table 11 provides the topping heater heat rates and the electrolysis power corresponding to the variables shown in Figure 3. Heater data are provided in Table 12.

Table 7. Stream data of combined cycle case.

Stream Name	Vapor	Temperature	Pressure	Molar Flow	Mass Flow
	Fraction	(C)	(MPa)	(kgmole/h)	(kg/s)
1	1	750	7	67.474	270.1
	1	750	7	60.736	243.13
	1	305.22	6.72	60.736	243.13
	1	308.71	6.72	67.474	270.1
5	1	322	7.071	67.474	270.1
6	1	750	7	6.7377	26.971
7	1	340.15	6.72	6.7377	26.971
8	1	725	7	6.7412	26.985
9	1	304.8	6.86	6.7412	26.985
10	1	315.15	7.14	6.7412	26.985
11	0	27.317	5.4	0.87296	15.727
12	0	26.894	5.4	1.3115	23.627
13	0.2711	268.86	5.3	1.3115	23.627
14	1	700	5.2	1.3115	23.627
15	1	650.93	5.2	1.4574	23.923
16	1	756.9	5.1	1.4574	23.923
17	1	670.93	4.9	1.4574	9.933
18	0.7726	144.07	4.8	1.4574	9.933
19	1	26	4.8	1.021	2.0724
20	0	26	4.8	0.43636	7.8607
21	0	26.052	5.4	0.43636	7.8607
22	0	26.052	5.4	0.43857	7.9004
23	1	35.491	5.2	0.14626	0.29685
24	1	35.491	5.2	0.14585	0.29604
25	0	27.317	5.4	4.82E-04	8.68E-03
	0	27.053	5.4	0.43731	7.879
_ 27 -	1	346.76	5.3	0.43731	7.879
	1	700	5.2	0.43731	7.879
	1	780	5.1	0.43731	7.879
30	1	755.74	4.9	0.87449	21.869
31	0.8172	203.63	4.8	0.87449	21.869
	0	27	4.8	0.43682 0.43682	7.8703
_ 33 - 24	0	27.052	5.4		7.8703
34 	0	27.052	5.4 6.86	0.43682	7.8703
From SG2 From SG 1	1 1	294 275 22	6.86 6.86	5.8456	23.4
—		375.32		0.89558	3.585
H2/Steam	1	800	5	1.4574	9.933

Stream Name	Vapor Fraction	Temperature (C)	Pressure (MPa)	Molar Flow (kgmole/h)	Mass Flow (kg/s)
Hydrogen Product	1	26	4.8	0.87477	1.7755
Hydrogen Recycle	1	26	4.8	0.14626	0.29685
Oxygen Product	1	27	4.8	0.43767	13.999
Steam/H2	1	800	5	1.4574	23.923
Sweep Gas In	1	800	5	0.43731	7.879
Sweep Gas/O2 Out	1	800	5	0.87449	21.869
Sweep Water In	0	26.85	0.10132	4.82E-04	8.68E-03
To SG1	1	725	7	0.89558	3.585
To SG 2	1	725	7	5.8456	23.4
Water In	0	26.85	0.10132	0.87296	15.727

Table 8. Composition data of combined cycle case.

Stream Name	Comp Mole Frac	Comp Mole Frac	Comp Mole Frac	Comp Mole Frac
	(H ₂)	(H₂O)	(O ₂)	(He)
_ 1	0	0	0	1
_ 2 _	0	0	0	1
_ 3 _	0	0	0	1
4	0	0	0	1
_ 5	0	0	0	1
6	0	0	0	1
_ 7 _	0	0	0	1
8	0	0	0	1
	0	0	0	1
10	0	0	0	1
_ 11	0	1	0	0
_ 12 _	0.00002	0.99998	0	0
_ 13	0.00002	0.99998	0	0
14	0.00002	0.99998	0	0
15	0.10001 0.10001	0.89999	0	0
_ 16 _ 17	0.10001	0.89999	0	0
_	0.7	0.3 0.3	0	0
	0.7	0.00086	0	0
_	0.99914	0.00086	0	0
21	0.00005	0.99995	0	0
- 21 22	0.00005	0.99995	0	0
_	0.99914	0.00086	0	0
	0.99914	0.00086	0	0
_	0.55514	0.00000	0	0
26	0	0.99986	0.00014	0

Stream Name	Comp Mole Frac (H ₂)	Comp Mole Frac (H ₂ O)	Comp Mole Frac (O ₂)	Comp Mole Frac (He)
27	0	0.99986	0.00014	0
28	0	0.99986	0.00014	0
29	0	0.99986	0.00014	0
30	0	0.5	0.5	0
31	0	0.5	0.5	0
32	0	0.99986	0.00014	0
33	0	0.99986	0.00014	0
34	0	0.99986	0.00014	0
From SG2	0	0	0	1
From SG 1	0	0	0	1
H2/Steam	0.7	0.3	0	0
Hydrogen Product	0.99914	0.00086	0	0
Hydrogen Recycle	0.99914	0.00086	0	0
Oxygen Product	0	0.0011	0.9989	0
Steam/H2	0.10001	0.89999	0	0
Sweep Gas In	0	0.99986	0.00014	0
Sweep Gas/O2 Out	0	0.5	0.5	0
Sweep Water In	0	1	0	0
To SG1	0	0	0	1
To SG 2	0	0	0	1
Water In	0	1	0	0

Table 9. Heat exchanger data for combined cycle case.

Name	Duty (kW)	UA (kJ/C-h)	LMTD (C)	MinimumApproach (C)
Sweep Hi Temp Recup	1,506	43,240	35	20
Hi Temp Steam/H2 Recup	6,394	212,000	30	20
Low Temp Steam/H2 Recup	37,400	428,800	87	25
_SG1	6,508	243,900	27	25
SG2	52,360	521,300	100	25
Sweep Low Temp Recup	23,410	246,900	95	25
IHX	57,400	2,296,000	25	25

Table 10. Pump data for combined cycle case.

Name	Water Pump	Water Recycle	Sweep Pump	Sweep Water Recycle Pump
		Pump		
Delta P (MPa)	5.299	0.6	5.299	0.6
Energy (kW)	110.4	6.239	6.09E-02	6.251
Feed Pressure (MPa)	0.1013	4.8	0.1013	4.8
Product Pressure (MPa)	5.4	5.4	5.4	5.4
Molar Flow (kgmole/h)	0.873	0.4364	4.82E-04	0.4368
Adiabatic Efficiency (%)	75	75	75	75

Table 11. Circulator data for combined cycle case

Name	Recirc	Circ1	Circ2
Feed Pressure (MPa)	4.80	6.72	6.86
Product Pressure (MPa)	5.20	7.07	7.14
Molar Flow (kgmole/s)	0.146	67.5	6.74
Energy (kW)	40.0	18,870	1,468
Adiabatic Efficiency	75	90	90
Polytropic Efficiency	75	91	90

Table 12. Heat data for combined cycle case.

Name	Steam/H2Topping Heater	Sweep Gas Topping Heater	Reactor	Electrolysis Unit
Duty (kW)	2,638	383	600,000	
Power (kW)				217025
Feed Temperature (C)	757	780	322	800
Product Temperature (C)	800	800	750	800

6. CONCLUSIONS

This report presents the results of a new INL reference design for a commercial-scale HTE plant for hydrogen production. The new reference HTE plant is driven by a 600 MWt HTGR coupled to either a Steam Rankine power cycle or a Combined power cycle (an Indirect Helium Brayton Cycle with a Steam Rankine Bottoming Cycle).

The following conclusions can be made.

- The HTE process coupled to a Steam Rankine cycle with a thermal efficiency of 44.4% produces hydrogen at a calculated rate of 1.85 kg/s and an overall hydrogen production efficiency of 42.8%. The process also produces 14.6 kg/s of oxygen
- The HTE process coupled to a combined cycle with a thermal efficiency of 42.5% produces hydrogen at a calculated rate of 1.78 kg/s and an overall hydrogen production efficiency of 41.0%. The process also produces 14.0 kg/s of oxygen.
- Based on the assumptions made for this analysis, the Rankine cycle alone produces
 more power than the combined cycle due to two reasons. First the Rankine cycle
 alone has a higher inlet steam temperature compared to the Rankine cycle within the
 combined cycle. Also the Brayton cycle operates at a lower efficiency than the
 Rankine cycle at these temperatures.
- At reactor outlet temperatures of 850°C or higher, the topping heaters could receive their heat from the reactor.
- High reactor outlet temperatures will produce more hydrogen due to high power cycle efficiency and more heat directly to electrolysis process.

This reference design provides the basis for planned future work, which will include sensitivity studies and economic analyses similar to those performed for the original reference design.

7. REFERENCES

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Appendix A

High Temperature Electrolysis with Rankine Cycle Process Flow Diagrams

The model of the HTE process with a Ranke power cycle and results in Appendix A were developed using HYSYS.Plant Version 2.2.2 (Build 3806) from Hyprotech Ltd. on a desktop computer running Microsoft Windows XP Professional Version 2002 Service Pack 3.

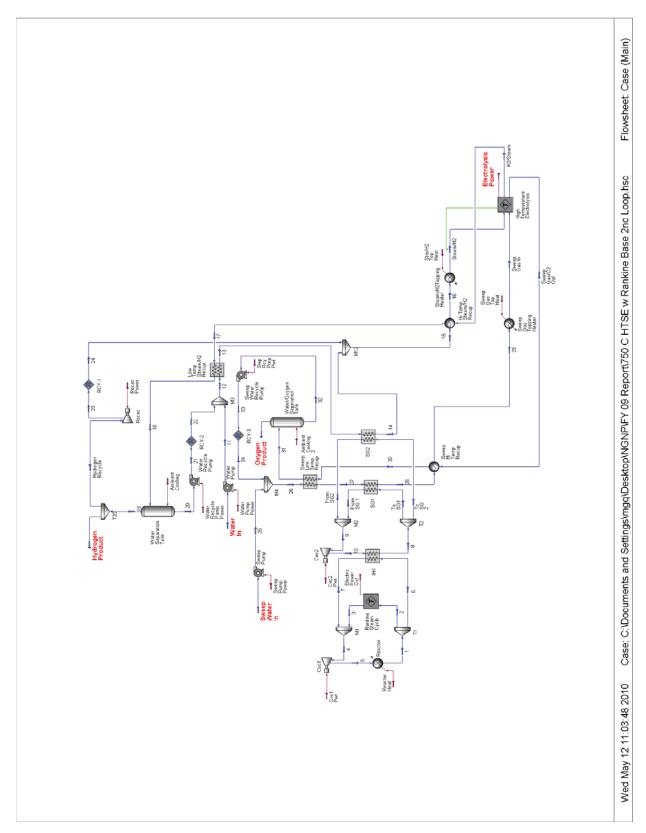


Figure A - 1 HTE Process Flow Diagram

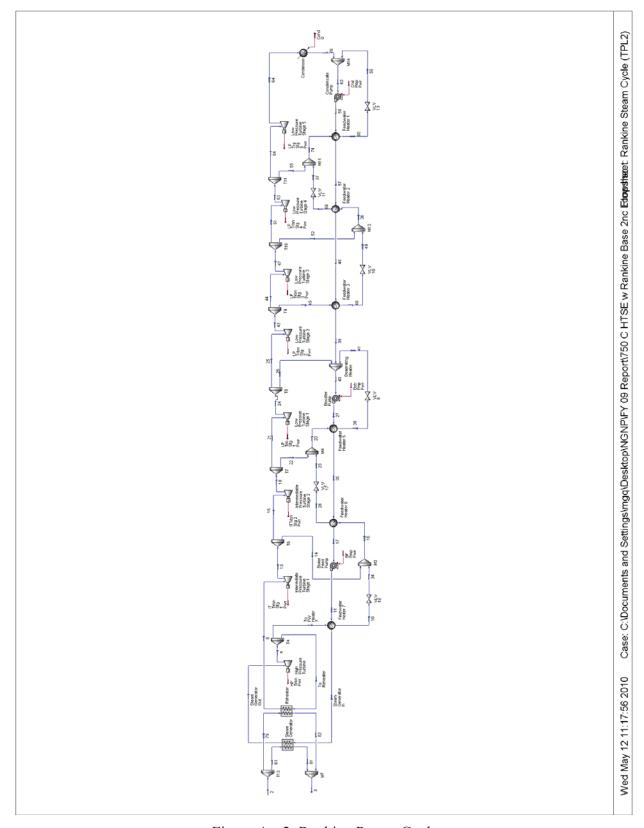


Figure A - 2 Rankine Power Cycle

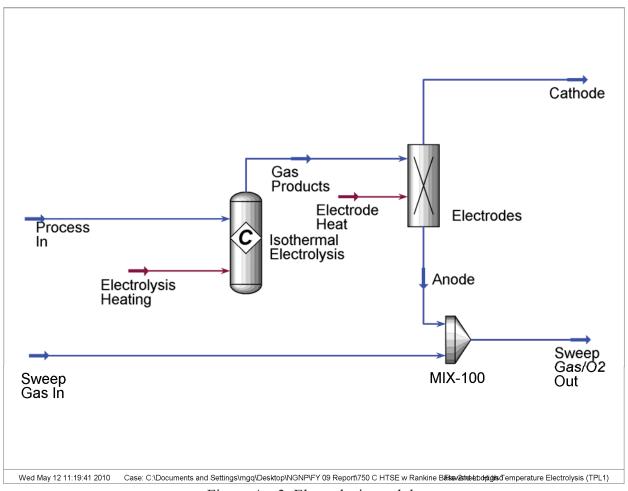


Figure A - 3 Electrolysis module

	Disc.			Case Name:	C:\Documents and Sett	ngs\mgq\Desktop\NGNI	P\FY 09 Report\750 C		
3	HYPROTEC	INL Calgary, A	Alberta	Unit Set:	NGNP				
4 5		CANADA		Date/Time:	Date/Time: Wed May 12 10:51:54 2010				
6	\A/	dala a a las	O (M-:	`					
8	wor	кроок:	Case (Main)					
9				Ct					
10				Streams	-		_		
11	Name		1	2	3	4	5		
12 13	Vapour Fraction	(0)	1.0000 750.00 *	1.0000 750.00	1.0000	1.0000 314.05 *	1.0000 322.00		
14	Temperature Pressure	(C) (MPa)	7.0000 *	7.0000	311.02 6.8600	6.8600	7.0710		
15	Molar Flow	(kgmole/s)	67.474	60.446	60.446	67.474	67.474		
16	Mass Flow	(kg/s)	270.10	241.97	241.97	270.10	270.10		
17	Liquid Volume Flow	(m3/h)	7837	7021	7021	7837	7837		
18	Heat Flow	(kW)	1.022e+006	9.152e+005	3.638e+005	4.103e+005	4.216e+005		
19	Molar Enthalpy	(kJ/kgmole)	1.514e+004	1.514e+004	6018	6081	6248		
20	Name		6	7	8	9	10		
21	Vapour Fraction		1.0000	1.0000	1.0000	1.0000	1.0000		
22	Temperature	(C)	750.00	340.11	725.00 *	304.76	315.11		
23	Pressure	(MPa)	7.0000	6.8600	7.0000 *	6.8600	7.1400		
24	Molar Flow	(kgmole/s)	7.0275	7.0275	7.0300	7.0300	7.0300		
25	Mass Flow	(kg/s)	28.131	28.131	28.141	28.141	28.141		
26	Liquid Volume Flow	(m3/h)	816.3	816.3	816.6	816.6	816.6		
27	Heat Flow	(kW)	1.064e+005	4.654e+004	1.028e+005	4.139e+004	4.292e+004		
28	Molar Enthalpy	(kJ/kgmole)	1.514e+004	6622	1.462e+004	5888	6106		
29 30	Name Vancus Fraction		11	0.0000	13	14 1,0000	1.0000		
31	Vapour Fraction Temperature	(C)	0.0000 27.317	26.897	0.2712 268.86	1.0000 700.00 *	650.93		
32	Pressure	(MPa)	5,4000	5.4000	5,3000	5.2000	5.2000		
33	Molar Flow	(kgmole/s)	0.91440	1.3679	1.3679	1.3679	1.5200		
34	Mass Flow	(kg/s)	16.473	24.643	24.643	24.643	24.951		
35	Liquid Volume Flow	(m3/h)	59.42	88.89	88.89	88.89	104.7		
36	Heat Flow	(kW)	-2.607e+005	-3.901e+005	-3.511e+005	-2.965e+005	-2.965e+005		
37	Molar Enthalpy	(kJ/kgmole)	-2.851e+005	-2.852e+005	-2.566e+005	-2.167e+005	-1.950e+005		
38	Name		16	17	18	19	20		
39	Vapour Fraction		1.0000	1.0000	0.7725	1.0000	0.0000		
40	Temperature	(C)	756.90	670.93	144.05	26.000	26.000		
41	Pressure	(MPa)	5.1000	4.9000	4.8000	4.8000	4.8000		
42	Molar Flow	(kgmole/s)	1.5200	1.5200	1.5200	1.0649	0.45512		
43	Mass Flow	(kg/s)	24.951	10.360	10.360	2.1614	8.1986		
			- : - : -						
44	Liquid Volume Flow	(m3/h)	104.7	140.2	140.2	110.6	29.58		
45	Heat Flow	(m3/h) (kVV)	-2.898e+005	140.2 -7.897e+004	-1.180e+005	-191.1	-1.298e+005		
45 46	Heat Flow Molar Enthalpy	(m3/h)	-2.898e+005 -1.906e+005	140.2 -7.897e+004 -5.195e+004	-1.180e+005 -7.762e+004	-191.1 -179.4	-1.298e+005 -2.852e+005		
45	Heat Flow Molar Enthalpy Name	(m3/h) (kVV)	-2.898e+005 -1.906e+005 21	140.2 -7.897e+004 -5.195e+004 22	-1.180e+005 -7.762e+004 23	-191.1 -179.4 24	-1.298e+005 -2.852e+005 25		
45 46 47	Heat Flow Molar Enthalpy Name Vapour Fraction	(m3/h) (kVV) (kJ/kgmole)	-2.898e+005 -1.906e+005	140.2 -7.897e+004 -5.195e+004	-1.180e+005 -7.762e+004	-191.1 -179.4	-1.298e+005 -2.852e+005 25 0.0000		
45 46 47 48	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature	(m3/h) (kW) (kJ/kgmole)	-2.898e+005 -1.906e+005 21 0.0000 26.052	140.2 -7.897e+004 -5.195e+004 22 0.0000	-1.180e+005 -7.762e+004 23 1.0000 35.491	-191.1 -179.4 24 1.0000 35.491 *	-1.298e+005 -2.852e+005 25 0.0000 27.317		
45 46 47 48	Heat Flow Molar Enthalpy Name Vapour Fraction	(m3/h) (kVV) (kJ/kgmole)	-2.898e+005 -1.906e+005 21 0.0000	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 *	-1.180e+005 -7.762e+004 23 1.0000	-191.1 -179.4 24 1.0000	-1.298e+005 -2.852e+005 25 0.0000		
45 46 47 48 49 50	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure	(m3/h) (kW) (kJ/kgmole) (C) (MPa)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ° 5.4000 °	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000	-191.1 -179.4 24 1.0000 35.491 ° 5.2000 °	-1.298e+005 -2.852e+005 25 0.0000 27.317 5.4000		
45 46 47 48 49 50	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000 0.45512 8.1986 29.58	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ° 5.4000 ° 0.45351 ° 8.1697 29.47	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84	-191.1 -179.4 24 1.0000 35.491 * 5.2000 * 0.15211 * 0.30873 15.80	-1.298e+005 -2.852e+005 25 0.0000 27.317 5.4000 5.0130e-004 9.0311e-003 3.258e-002		
45 46 47 48 49 50	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000 0.45512 8.1986 29.58 -1.298e+005	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ° 5.4000 ° 0.45351 ° 8.1697 29.47 -1.293e+005	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84 14.33	-191.1 -179.4 24 1.0000 35.491 ' 5.2000 ' 0.15211 ' 0.30873 15.80 14.29	-1.298e+005 -2.852e+005 25 0.0000 27.317 5.4000 5.0130e-004 9.0311e-003 3.258e-002 -142.9		
45 46 47 48 49 50 61 52 53 54 55	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000 0.45512 8.1986 29.58 -1.298e+005 -2.852e+005	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ° 5.4000 ° 0.45351 ° 8.1697 29.47 -1.293e+005 -2.852e+005	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84 14.33 93.95	-191.1 -179.4 24 1.0000 35.491 * 5.2000 * 0.15211 * 0.30873 15.80 14.29 93.95	-1.298+005 -2.852e+005 25 0.0000 27.317 5.04000 5.0130e-004 9.0311e-003 3.258e-002 -142.9 -2.851e+005		
45 46 47 48 49 50 51 52 53 54 55 56	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000 0.45512 8.1986 29.58 -1.298e+005 -2.852e+005	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ' 5.4000 ' 0.45351 ' 8.1697 29.47 -1.293e+005 -2.852e+005	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84 14.33 93.95	-191.1 -179.4 24 1.0000 35.491 ' 5.2000 ' 0.15211 ' 0.30873 15.80 14.29 93.95	-1.298e+005 -2.852e+005 25 0.0000 27.317 5.4000 5.0130e-004 9.0311e-003 3.258e-002 -142.9 -2.851e+005		
45 46 47 48 49 50 61 52 53 54 55	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000 0.45512 8.1986 29.58 -1.298e+005 -2.852e+005 26	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ' 5.4000 ' 0.45351 ' 8.1697 29.47 -1.293e+005 -2.852e+005 27	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84 14.33 93.95 28	-191.1 -179.4 24 1.0000 35.491 5.2000 0.15211 0.30873 15.80 14.29 93.95 29	-1.298e+005 -2.852e+005 25 0.0000 27.317 5.4000 5.0130e-004 9.0311e-003 3.258e-002 -142.9 -2.851e+005 30		
45 46 47 48 49 50 51 52 53 54 55 56	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000 0.45512 8.1986 29.58 -1.298e+005 -2.852e+005 26 0.0000 27.053	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ' 5.4000 ' 0.45351 ' 8.1697 29.47 -1.293e+005 -2.852e+005 27 1.0000 346.69	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84 14.33 93.95 28 1.0000 700.00	-191.1 -179.4 24 1.0000 35.491 5.2000 0.15211 0.30873 15.80 14.29 93.95 29 1.0000 780.00	-1.298e+005 -2.852e+005 25 0.0000 27.317 5.4000 5.0130e-004 9.0311e-003 3.258e-002 -142.9 -2.851e+005 30 1.0000 755.74		
45 46 47 48 49 50 61 52 53 54 55 56 57 58	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000 0.45512 8.1986 29.58 -1.298e+005 -2.852e+005 26 0.0000 27.053 5.4000	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ' 5.4000 ' 0.45351 ' 8.1697 29.47 -1.293e+005 -2.852e+005 27 1.0000 346.69 5.3000	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84 14.33 93.95 28 1.0000 700.00 5.2000	-191.1 -179.4 24 1.0000 35.491 * 5.2000 * 0.15211 * 0.30873 15.80 14.29 93.95 29 1.0000 780.00 5.1000	-1.298e+005 -2.852e+005 25 0.0000 27.317 5.4000 5.0130e-004 9.0311e-003 3.258e-002 -142.9 -2.851e+005 30 1.0000 755.74 4.9000		
45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s)	-2.898e+005 -1.906e+005 21 0.0000 26.055 5.4000 0.45512 8.1986 29.58 -1.298e+005 -2.852e+005 26 0.0000 27.053 5.4000 0.45611	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ° 5.4000 ° 0.45351 ° 8.1697 29.47 -1.293e+005 -2.852e+005 27 1.0000 346.69 5.3000 0.45611	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84 14.33 93.95 28 1.0000 700.00 5.2000 0.45611	-191.1 -179.4 24 1.0000 35.491 * 5.2000 * 0.15211 * 0.30873 15.80 14.29 93.95 29 1.0000 780.00 5.1000 0.45611	-1.298e+005 -2.852e+005 25 0.0000 27.317 5.4000 5.0130e-004 9.0311e-003 3.258e-002 -142.9 -2.851e+005 30 1.0000 755.74 4.9000 0.91209		
45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Mass Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000 0.45512 8.1986 29.58 -1.298e+005 -2.852e+005 26 0.0000 27.053 5.4000 0.45611 8.2178 *	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ' 5.4000 ' 0.45351 ' 8.1697 29.47 -1.293e+005 -2.852e+005 27 1.0000 346.69 5.3000 0.45611 8.2178	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84 14.33 93.95 28 1.0000 700.00 5.2000 0.45611 8.2178	-191.1 -179.4 24 1.0000 35.491 ' 5.2000 ' 0.15211 ' 0.30873 15.80 14.29 93.95 29 1.0000 780.00 5.1000 0.45611 8.2178	-1.298+005 -2.852e+005 25 0.0000 27.317 5.4000 5.0130e-004 9.0311e-003 3.258e-002 -142.9 -2.851e+005 30 1.0000 755.74 4.9000 0.91209 22.809		
45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 61	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kgmole/s) (kg/s)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000 0.45512 8.1986 29.58 -1.298e+005 -2.852e+005 26 0.0000 27.053 5.4000 0.45611 8.2178 29.64	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 * 5.4000 * 0.45351 * 8.1697 29.47 -1.293e+005 -2.852e+005 27 1.0000 346.69 5.3000 0.45611 8.2178 29.64	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84 14.33 93.95 28 1.0000 700.00 5.2000 0.45611 8.2178 29.64	-191.1 -179.4 24 1.0000 35.491 ' 5.2000 ' 0.15211 ' 0.30873 15.80 14.29 93.95 29 1.0000 780.00 5.1000 0.45611 8.2178 29.64	-1.298e+005 -2.852e+005 25 0.0000 27.317 5.4000 5.0130e-004 9.0311e-003 3.258e-002 -142.9 -2.851e+005 30 1.0000 755.74 4.9000 0.91209 22.809 75.81		
45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61	Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Mass Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s)	-2.898e+005 -1.906e+005 21 0.0000 26.052 5.4000 0.45512 8.1986 29.58 -1.298e+005 -2.852e+005 26 0.0000 27.053 5.4000 0.45611 8.2178 *	140.2 -7.897e+004 -5.195e+004 22 0.0000 26.052 ' 5.4000 ' 0.45351 ' 8.1697 29.47 -1.293e+005 -2.852e+005 27 1.0000 346.69 5.3000 0.45611 8.2178	-1.180e+005 -7.762e+004 23 1.0000 35.491 5.2000 0.15254 0.30961 15.84 14.33 93.95 28 1.0000 700.00 5.2000 0.45611 8.2178	-191.1 -179.4 24 1.0000 35.491 ' 5.2000 ' 0.15211 ' 0.30873 15.80 14.29 93.95 29 1.0000 780.00 5.1000 0.45611 8.2178	-1.298e+005 -2.852e+005 25 0.0000 27.317 5.4000 5.0130e-004 9.0311e-003 3.258e-002 -142.9 -2.851e+005 30 1.0000 755.74 4.9000 0.91209 22.809		

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6 7 8	Wor	kbook:	Case (Main) (continue	ed)		
9 10			:	Streams (continu	ıed)		
11	Name		31	32	33	34	Ambient Cooling
12	Vapour Fraction		0.8172	0.0000	0.0000	0.0000	
13	Temperature	(C)	203.63	27.000	27.052	27.052 *	
14	Pressure	(MPa)	4.8000	4.8000	5.4000	5.4000 *	
15 16	Molar Flow	(kgmole/s)	0.91209	0.45561	0.45561	0.45561 *	
17	Mass Flow Liquid Volume Flow	(kg/s) (m3/h)	22.809 75.81	8.2087 29.61	8.2087 29.61	8.2088 29.61	
18	Heat Flow	(m3/n) (kW)	-1.112e+005	-1.299e+005	-1.299e+005	-1.299e+005	-1.203e+004
19	Molar Enthalpy	(kJ/kgmole)	-1.112e+005	-1.299e+005 -2.851e+005	-2.851e+005	-1.299e+005 -2.851e+005	-1.2036+004
20	Name	(Ko/Kgiriole)	Ambient Cooling 2	Circ1 Pwr	Circ2 Pwr	Electric Power Out	Electrolysis Power
21	Vapour Fraction		Ambient Cooling 2			Liectric Fower Out	
22	Temperature	(C)					
23	Pressure	(MPa)					
24	Molar Flow	(kgmole/s)					
25	Mass Flow	(kg/s)					
26	Liquid Volume Flow	(m3/h)					
27	Heat Flow	(kW)	-1.897e+004	1.128e+004	1531	2.489e+005	-2.264e+005
28	Molar Enthalpy	(kJ/kgmole)					
29	Name		From SG2	From SG 1	H2/Steam	Hydrogen Product	Hydrogen Recycle
30	Vapour Fraction		1.0000	1.0000	1.0000	1.0000	1.0000
31	Temperature	(C)	293.92	375.42	800.00	26.000	26.000
32 33	Pressure	(MPa)	6.8600	6.8600	5.0000	4.8000	4.8000
	Molar Flow	(kgmole/s)	6.0955	0.93455	1.5200	0.91236	0.15254
2.4	Mass Flour	/leale\	24 400	2 7440	10.200	1 0510	0.20064
34	Mass Flow	(kg/s)	24.400	3.7410	10.360	1.8518	0.30961
35	Liquid Volume Flow	(m3/h)	708.0	108.6	140.2	94.75	15.84
35 36	Liquid Volume Flow Heat Flow	(m3/h) (kVV)	708.0 3.452e+004	108.6 6874	140.2 -7.230e+004	94.75 -163.7	15.84 -27.37
35	Liquid Volume Flow	(m3/h)	708.0 3.452e+004 5663	108.6	140.2	94.75	15.84
35 36 37 38 39	Liquid Volume Flow Heat Flow Molar Enthalpy	(m3/h) (kVV)	708.0 3.452e+004	108.6 6874 7356	140.2 -7.230e+004 -4.757e+004	94.75 -163.7 -179.4	15.84 -27.37 -179.4
35 36 37 38	Liquid Volume Flow Heat Flow Molar Enthalpy Name	(m3/h) (kVV)	708.0 3.452e+004 5663 Oxygen Product	108.6 6874 7356 Process Heat 1	140.2 -7.230e+004 -4.757e+004 Reactor Heat	94.75 -163.7 -179.4 Recirc Power	15.84 -27.37 -179.4 Steam/H2
35 36 37 38 39 40 41	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction	(m3/h) (kW) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000	108.6 6874 7356 Process Heat 1	140.2 -7.230e+004 -4.757e+004 Reactor Heat	94.75 -163.7 -179.4 Recirc Power	15.84 -27.37 -179.4 Steam/H2 1.0000
35 36 37 38 39 40 41 42	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature	(m3/h) (kW) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 °	108.6 6874 7356 Process Heat 1	140.2 -7.230e+004 -4.757e+004 Reactor Heat	94.75 -163.7 -179.4 Recirc Power	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 *
35 36 37 38 39 40 41 42 43	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure	(m3/h) (kW) (kJ/kgmole) (C) (MPa)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 * 4.8000	108.6 6874 7356 Process Heat 1	140.2 -7.230e+004 -4.757e+004 Reactor Heat 	94.75 -163.7 -179.4 Recirc Power	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 '
35 36 37 38 39 40 41 42 43	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 ° 4.8000 0.45648 14.600 46.20	108.6 6874 7356 Process Heat 1 	140.2 -7.230e+004 -4.757e+004 Reactor Heat	94.75 -163.7 -179.4 Recirc Power	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ° 5.0000 ° 1.5200 24.951 ° 104.7
35 36 37 38 39 40 41 42 43 44	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 * 4.8000 0.45648 14.600 46.20	108.6 6874 7356 Process Heat 1 	140.2 -7.230e+004 -4.757e+004 Reactor Heat	94.75 -163.7 -179.4 Recirc Power	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005
35 36 37 38 39 40 41 42 43 44 45 46	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0	108.6 6874 7356 Process Heat 1 2.384e-004	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005	94.75 -163.7 -179.4 Recirc Power	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005
35 36 37 38 39 40 41 42 43 44 45 46 47	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005
35 36 37 38 39 40 41 42 43 44 45 46 47	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005
35 36 37 38 39 40 41 42 43 44 45 46 47 48	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Molar Flow Mass Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Liquid Volume Flow Liquid Volume Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178 29.64	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Molar Flow Mass Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 * 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Liquid Volume Flow Heat Flow Molar Flow Molar Flow Molar Flow Molar Flow Molar Flow Mass Flow Liquid Volume Flow Heat Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kgmole/s) (kg/s) (kg/s) (kg/s) (kg/s)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat 2752	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178 29.64 -9.687e+004	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat 399.4	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81 -8.525e+004	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Flow Mass Flow Liquid Volume Flow Heat Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kgmole/s) (kg/s) (kg/s) (kg/s) (kg/s)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 ' 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat 2752	108.6 6874 7356 Process Heat 1 2.384e-004 2.384e-004 800.00 5.0000 0.45611 8.2178 29.64 -9.687e+004 -2.124e+005	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat 399.4	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81 -8.525e+004 -9.346e+004	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ° 5.0000 ° 1.5200 24.951 ° 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power 6.343e-002
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Mass Flow Mass Flow Mass Flow Heat Flow Heat Flow Molar Enthalpy Name	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kgmole/s) (kg/s) (m3/h) (kg/s) (kg/s)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 ' 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat 2752 Sweep Water In	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178 29.64 -9.687e+004 -2.124e+005 Swp Rcy Pmp Pwr	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat 399.4 To SG1	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81 -8.525e+004 -9.346e+004 To SG 2	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power 6.343e-002 Water In
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 61 52 53 54 55 56 57 58	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kV) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (kg/s) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 ' 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat 2752 Sweep Water In 0.0000	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178 29.64 -9.687e+004 -2.124e+005 Swp Rcy Pmp Pwr	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat 399.4 To SG1 1.0000	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81 -8.525e+004 -9.346e+004 To SG 2	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power 6.343e-002 Water In
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 61 52 53 54 55 56 57 58 59 60	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (m3/h) (kW) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 * 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat 2752 Sweep Water In 0.0000 26.850 * 0.10132 * 5.0130e-004	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178 29.64 -9.687e+004 -2.124e+005 Swp Rcy Pmp Pwr	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat 399.4 To SG1 1.0000 725.00 7.0000 0.93455	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81 -8.525e+004 -9.346e+004 To SG 2 1.0000 725.00 7.0000 6.0955	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ° 5.0000 ° 1.5200 24.951 ° 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power 6.343e-002 Water In 0.0000 26.850 ° 0.10132 ° 0.91440
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Flow Mass Flow Liquid Volume Flow Heat Flow Temperature Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Mass Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (kg/s) (kJ/kgmole) (C) (MPa) (kgmole/s) (kW) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat 2752 Sweep Water In 0.0000 26.850 0.10132 5.0130e-004 9.0311e-003	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178 29.64 -9.687e+004 -2.124e+005 Swp Rcy Pmp Pwr	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 * Sweep Gas Top Heat 399.4 To SG1 1.0000 725.00 7.0000 0.93455 3.7410 *	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81 -8.525e+004 -9.346e+004 To SG 2 1.0000 725.00 7,0000 6.0955 24.400 °	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power 6.343e-002 Water In 0.0000 26.850 ' 0.10132 ' 0.91440 16.473
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (kW) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 ' 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat 2752 Sweep Water In 0.0000 26.850 ' 0.10132 ' 5.0130e-004 9.0311e-003 3.258e-002	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178 29.64 -9.687e+004 -2.124e+005 Swp Rcy Pmp Pwr	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat 399.4 To SG1 1.0000 725.00 7.0000 0.93455 3.7410 108.6	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81 -8.525e+004 -9.346e+004 To SG 2 1.0000 725.00 7.0000 6.0955 24.400 ' 708.0	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power 6.343e-002 Water In 0.0000 26.850 ' 0.10132 ' 0.91440 16.473 59.42
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 61 52 53 54 55 56 57 58 59 60 61 62 63	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Flow Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Liquid Volume Flow Heat Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat 2752 Sweep Water In 0.0000 26.850 0.10132 5.0130e-004 9.0311e-003 3.258e-002 -143.0	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178 29.64 -9.687e+004 -2.124e+005 Swp Rcy Pmp Pwr	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat 399.4 To SG1 1.0000 725.00 7.0000 0.93455 3.7410 108.6 1.366e+004	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81 -8.525e+004 -9.346e+004 To SG 2 1.0000 725.00 7.0000 6.0955 24.400 708.0	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power 6.343e-002 Water In 0.0000 26.850 ' 0.10132 ' 0.91440 16.473 59.42 -2.608e+005
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 61 52 53 54 55 56 57 58 59 60 61 62 63 64	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (kW) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 ' 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat 2752 Sweep Water In 0.0000 26.850 ' 0.10132 ' 5.0130e-004 9.0311e-003 3.258e-002	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178 29.64 -9.687e+004 -2.124e+005 Swp Rcy Pmp Pwr	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat 399.4 To SG1 1.0000 725.00 7.0000 0.93455 3.7410 108.6	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81 -8.525e+004 -9.346e+004 To SG 2 1.0000 725.00 7.0000 6.0955 24.400 ' 708.0	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power 6.343e-002 Water In 0.0000 26.850 ' 0.10132 ' 0.91440 16.473 59.42
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 61 52 53 54 55 56 57 58 59 60 61 62 63	Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Flow Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Liquid Volume Flow Heat Flow	(m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole)	708.0 3.452e+004 5663 Oxygen Product 1.0000 27.000 4.8000 0.45648 14.600 46.20 -293.1 -642.0 Stm/H2 Top Heat 2752 Sweep Water In 0.0000 26.850 0.10132 5.0130e-004 9.0311e-003 3.258e-002 -143.0 -2.853e+005	108.6 6874 7356 Process Heat 1 2.384e-004 Sweep Gas In 1.0000 800.00 5.0000 0.45611 8.2178 29.64 -9.687e+004 -2.124e+005 Swp Rcy Pmp Pwr	140.2 -7.230e+004 -4.757e+004 Reactor Heat 6.000e+005 Sweep Gas Top Heat 399.4 To SG1 1.0000 725.00 7.0000 0.93455 3.7410 108.6 1.366e+004 1.462e+004	94.75 -163.7 -179.4 Recirc Power 41.70 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.91209 22.809 75.81 -8.525e+004 -9.346e+004 To SG 2 1.0000 725.00 7.0000 6.0955 24.400 708.0	15.84 -27.37 -179.4 Steam/H2 1.0000 800.00 ' 5.0000 ' 1.5200 24.951 ' 104.7 -2.870e+005 -1.888e+005 Sweep Pump Power 6.343e-002 Water In 0.0000 26.850 ' 0.10132 ' 0.91440 16.473 59.42 -2.608e+005

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		N. In. a set of			ingsungqibeskiopuvoivi	- Tr T 09 Report(750 C I
Workbook: Case (Main) (continued)	- HYPROTECH	Аірепа				
Workbook: Case (Main) (continued)			Date/Time:	Wed May 12 10:51:54	2010	
Name	☑ Workbook:	Case (Main	ı) (continue	ed)		
1 Name	_	;	Streams (continu	ıed)		
13 Pressure (MPa)		Water Pump Power	Water Recycle Pump			
More						
Mass Flow (kgmolefs)	- '					
Mars Flow						
	()					
19 Heaf Flow (WJ 115.7 6.507						
Molar Enthalpy (kil/kgmole)	()					
Name						
1	_		Composition			
Comp Mole Frac (H2O)		1	2	3	4	5
Comp Mole Frac (Noygen)		0.00000 *	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Nitrogen)		0.00000 *	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (COZ)						0.00000
Comp Mole Frac (Argon)						0.00000
Comp Mole Frac (Hellum)						0.00000
Name						0.00000
Comp Mole Frac (Hydrogen)						1.00000
Comp Mole Frac (H2O)						
Comp Mole Frac (Nitrogen)	_ ` ` ` ` ` ` `					
Comp Mole Frac (Nitrogen)						0.00000
Comp Mole Frac (CO2)						0.00000
Comp Mole Frac (Helium)	-					0.00000
Name		0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Hydrogen)	37 Comp Mole Frac (Helium)	1.00000	1.00000	1.00000	1.00000	1.00000
Comp Mole Frac (H2O)	38 Name	11	12	13	14	15
Comp Mole Frac (Oxygen)		0.00000	0.00002	0.00002	0.00002	0.10000
Comp Mole Frac (Nitrogen) 0.00000 0.0000						0.90000
Comp Mole Frac (CO2)						0.00000
Comp Mole Frac (Argon) 0.000000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	- · · · · · · · · · · · · · · · · · · ·					0.00000
Comp Mole Frac (Helium)						0.00000
Name						
Comp Mole Frac (Hydrogen)						
48 Comp Mole Frac (H2O) 0.90000 0.30000 0.30000 0.00086 0.998 49 Comp Mole Frac (Oxygen) 0.00000 0.00000 0.00000 0.00000 0.00000 50 Comp Mole Frac (Nitrogen) 0.00000 0.00000 0.00000 0.00000 0.00000 51 Comp Mole Frac (Argon) 0.00000 0.00000 0.00000 0.00000 0.00000 52 Comp Mole Frac (Argon) 0.00000 0.00000 0.00000 0.00000 0.00000 53 Comp Mole Frac (Helium) 0.00000 0.00000 0.00000 0.00000 0.00000 54 Name 21 22 23 24 25 55 Comp Mole Frac (Hydrogen) 0.00005 0.00005 0.99914 0.99914 0.99914 0.0000 56 Comp Mole Frac (H2O) 0.99995 0.99995 0.99995 0.00086 0.00086 1.000 57 Comp Mole Frac (Oxygen) 0.000000						0.00005
49 Comp Mole Frac (Oxygen) 0.00000	comp more ride (rigaregon)					0.99995
50 Comp Mole Frac (Nitrogen) 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 51 Comp Mole Frac (CO2) 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.0000 0.0000 0.00000 <t< td=""><td></td><td></td><td></td><td></td><td></td><td>0.00000</td></t<>						0.00000
51 Comp Mole Frac (CO2) 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.0000 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td>0.00000</td>						0.00000
55 Comp Mole Frac (Helium) 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.0000 </td <td>51 Comp Mole Frac (CO2)</td> <td>0.00000</td> <td>0.00000</td> <td></td> <td></td> <td>0.00000</td>	51 Comp Mole Frac (CO2)	0.00000	0.00000			0.00000
54 Name 21 22 23 24 25 55 Comp Mole Frac (Hydrogen) 0.00005 0.00005* 0.99914 0.99914* 0.99914* 0.000 56 Comp Mole Frac (H2O) 0.99995 0.99995* 0.00086 0.00086* 1.000 57 Comp Mole Frac (Oxygen) 0.00000 0.00000* 0.00000						0.00000
55 Comp Mole Frac (Hydrogen) 0.00005 0.00005* 0.99914 0.99914* 0.99914* 0.000 66 Comp Mole Frac (H2O) 0.99995 0.99995* 0.00086 0.00086* 1.000 57 Comp Mole Frac (Oxygen) 0.00000 0.00000* 0.00000 0.00000* 0.0000 58 Comp Mole Frac (Nitrogen) 0.00000 0.00000* 0.00000 0.00000* 0.0000 59 Comp Mole Frac (Argon) 0.00000 0.00000* 0.00000 0.00000 0.0000 60 Comp Mole Frac (Helium) 0.00000 0.00000* 0.00000 0.00000 0.00000 64 65 66 67 67 68 </th <th></th> <th></th> <th></th> <th></th> <th></th> <th>0.00000</th>						0.00000
56 Comp Mole Frac (H2O) 0.99995 0.99995 ' 0.00086 ' 0.00086 ' 1.000 57 Comp Mole Frac (Oxygen) 0.00000 ' 0.00000 ' 0.00000 ' 0.00000 ' 0.0000 58 Comp Mole Frac (Nitrogen) 0.00000 ' 0.0						
57 Comp Mole Frac (Oxygen) 0.00000 0.00000 °						0.00000
65 Comp Mole Frac (Nitrogen) 0.00000 0.00000 °						1.00000
59 Comp Mole Frac (CO2) 0.000000						0.00000
60 Comp Mole Frac (Argon) 0.00000 0.00000°						0.00000
61 Comp Mole Frac (Helium) 0.000000						0.00000
62 63 64 65						0.00000
63 64 65	62					
	63 64 65					
66 Hyprotech Ltd. HYSYS.Plant v2.2.2 (Build 3806) Page 3 of	66 Hyprotech Ltd.	HY	SYS Plant v2 2 2 (Ruile	d 3806)		Page 3 of 22

2	INL		Case Name:	C:\Documents and Sett	ings\mgq\Desktop\NGNI	P\FY 09 Report\750 C H		
3	Calgary, A	Alberta	Unit Set:	NGNP				
5	CANADA		Date/Time:	Wed May 12 10:51:54	2010			
6								
7	Workbook:	Case (Main) (continue	ed)				
9 10		Co	mposition (cont	mposition (continued)				
11	Name	26	27	28	29	30		
12	Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000		
13	Comp Mole Frac (H2O)	0.99986	0.99986	0.99986	0.99986	0.50001		
14	Comp Mole Frac (Oxygen)	0.00014	0.00014	0.00014	0.00014	0.49999		
15	Comp Mole Frac (Nitrogen)	0.00000	0.00000	0.00000	0.00000	0.00000		
16 17	Comp Mole Frac (CO2) Comp Mole Frac (Argon)	0.00000	0.00000	0.00000	0.00000	0.00000		
18	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000		
19	Name	31	32	33	34	From SG2		
20	Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000 *	0.00000		
21	Comp Mole Frac (H2O)	0.50001	0.99986	0.99986	0.99986 *	0.00000		
22	Comp Mole Frac (Oxygen)	0.49999	0.00014	0.00014	0.00014 *	0.00000		
23	Comp Mole Frac (Nitrogen)	0.00000	0.00000	0.00000	0.00000 *	0.00000		
24	Comp Mole Frac (CO2)	0.00000	0.00000	0.00000	0.00000 *	0.00000		
25	Comp Mole Frac (Argon)	0.00000	0.00000	0.00000	0.00000 *	0.00000		
26	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000 *	1.00000		
27	Name	From SG 1	H2/Steam	Hydrogen Product	Hydrogen Recycle	Oxygen Product		
28	Comp Mole Frac (Hydrogen)	0.00000	0.70000	0.99914	0.99914	0.00000		
29	Comp Mole Frac (H2O)	0.00000	0.30000	0.00086	0.00086	0.00110		
30 31	Comp Mole Frac (Oxygen)	0.00000	0.00000	0.00000	0.00000	0.99890		
32	Comp Mole Frac (Nitrogen) Comp Mole Frac (CO2)	0.00000	0.00000	0.00000	0.00000	0.00000		
33	Comp Mole Frac (CO2)	0.00000	0.00000	0.00000	0.00000	0.00000		
34	Comp Mole Frac (Algori)	1.00000	0.00000	0.00000	0.00000	0.00000		
35	Name	Steam/H2	Sweep Gas In	Sweep Gas/O2 Out	Sweep Water In	To SG1		
36	Comp Mole Frac (Hydrogen)	0.10000	0.00000	0.00000	0.00000 *	0.00000 *		
37	Comp Mole Frac (H2O)	0.90000	0.99986	0.50001	1.00000 *	0.00000 *		
38	Comp Mole Frac (Oxygen)	0.00000	0.00014	0.49999	0.00000 *	0.00000 *		
39	Comp Mole Frac (Nitrogen)	0.00000	0.00000	0.00000	0.00000 *	0.00000 *		
40	Comp Mole Frac (CO2)	0.00000	0.00000	0.00000	0.00000 *	0.00000 *		
41	Comp Mole Frac (Argon)	0.00000	0.00000	0.00000	0.00000 *	0.00000 *		
42	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000 *	1.00000 *		
43	Name	To SG 2	Water In					
44 45	Comp Mole Frac (Hydrogen)	0.00000 *	0.00000*					
46	Comp Mole Frac (H2O) Comp Mole Frac (Oxygen)	0.00000 *	1.00000 *					
47	Comp Mole Frac (Oxygen) Comp Mole Frac (Nitrogen)	0.00000 *	0.00000 * 0.00000 *					
48	Comp Mole Frac (CO2)	0.00000	0.00000					
49	Comp Mole Frac (Argon)	0.00000 *	0.00000					
50	Comp Mole Frac (Helium)	1.00000 '	0.00000 *					
51			Coolers					
52 53	Name		0001613					
54	Duty (kW)							
55	Feed Temperature (C)							
56	Product Temperature (C)							
57	, , ,		Heat Exchange	rs				
58 59	Name	Sweep Hi Temp Recu						
60	Duty (kW)	1570	6668					
61	UA (W/C)	4.510e+004	2.211e+005					
62	LMTD (C)	34.82	30.15					
63	Minimum Approach (C)	20.00	20.00					
64								
65			N/0 B/ 1 2 2 2 /	10000				
66	Hyprotech Ltd. Licensed to: INL	HYS	SYS.Plant v2.2.2 (Buil	d 3806)		Page 4 of 22 * Specified by user.		

1	<u></u>				Case Name: (C:\Documents and Setti	inaclmaal C	lookton/NGNID	EV 00 Papart\750 C
2		INL					ngsungqıc	Desktopinon-	F 1 09 Reporti/50 C
3	HYPROTECH	Calgary, A CANADA	Nberta			NGNP			
5	pa-				Date/Time: \	Wed May 12 10:51:54	2010		
6 7 8	Workb	ook:	Case (Ma	in) (d	ontinue	ed)			
9 10					Heaters				
11	Name		Steam/H2Topping	He Swe	ep Gas Topping	Reactor			
12	Duty	(kW)	275	52	399.4	6.000e+005 *			
13	Feed Temperature	(C)	756	_	780.0	322.0			
14 15	Product Temperature	(C)	800	.0 *	0.008	750.0 *			
16					LNGs				
17	Name		Low Temp Steam			SG2	_	Low Temp Re	IHX
18	UA (Calculated)	(W/C)	4.476e+00		2.537e+005	5.440e+005	2	.575e+005	2.395e+006
19 20	LMTD	(C)	87.1		26.76 *	100.4 *		94.80 *	25.00
20	Exchanger Cold Duty Minimum Approach	(kW)	3.901e+00 25.0		6790 25.00	5.460e+004 25.00	- 2	.441e+004 25.00	5.986e+004 24.99
22	Tanaman rapproducti	(0)	25.0					20.00	24.55
23					ompressors				
24	Name		Recirc	Circ		Circ2			
25	Feed Pressure	(MPa)	4.80	_	6.860	6.860			
26 27	Product Pressure Molar Flow (F	(MPa) kgmole/s)	5.20 0.152		7.071 67.47	7.140 7.030			
	Energy	(kW)	41.7		1.128e+004	1531			
28 29	Adiabatic Efficiency	(1117)		75 .	90 *	90 *			
30	Polytropic Efficiency		7	75	90	90			
31	-				Expanders				
32 33	Name				Expanders				
34	Feed Pressure	(MPa)							
35	Product Pressure	(MPa)							
36	Molar Flow (F	(gmole/s)							
37	Energy	(kW)							
38	Adiabatic Efficiency								
39 40	Polytropic Efficiency								
41					Pumps				
42	Name		Water Pump	Wate	er Recycle Pump	Sweep Pump	Sweep \	Water Recyc	
43	Delta P	(MPa)	5.29	99	0.6000	5.299		0.6000	
44	Energy	(kW)	115		6.507	6.343e-002		6.520	
45	Feed Pressure	(MPa)	0.101		4.800	0.1013 *		4.800	
46 47	Product Pressure Molar Flow (F	(MPa) kgmole/s)	5.40 0.914		5.400 0.4551	5.400 5.013e-004		5.400 0.4556	
48	Adiabatic Efficiency	(%)	75.0		75.00 *	75.00 °		75.00 *	
48 49		(,,,,		- 1	Unit Ops	. 5.30		. 5.00	
50									
51	Operation Name	Ope	eration Type	Ct ""	Feeds	Products		Ignored	Calc. Level
52 53 54	High Temperature Electrolys	Standard	Sub-Flowsheet	Steam/H: Sweep G		H2/Steam Sweep Gas/O2 O		No	2500
54	nigh remperature Electrolys	Standard	Sub-Flowsneet	Process		Electrolysis Power		NO	2500
55	<u> </u>			2		3			
55 56	Rankine Steam Cycle	Standard	Sub-Flowsheet			Electric Power Ou	t	No	2500
57	Electrolysis Input and Outpu							No	500.0
58	Efficiency	Spreadsh	eet					No	500.0
59 60	Steam/H2Topping Heater	Heater	}	16 Stm/H2 T	on Heat	Steam/H2		No	500.0
61				Stm/H2 T 29	ор пеат	Sweep Gas In			+
61 62	Sweep Gas Topping Heater	Heater	ł		as Top Heat	55cp Gas III		No	500.0
63 64	Reactor	Heater		5	,	1		No	500.0
64				Reactor	Heat				
65	T20	Tee		19		Hydrogen Product		No	500.0
66	Hyprotech Ltd.			HYSYS.P	lant v2.2.2 (Build	13806)			Page 5 of 22

1			Coor Name (C)	Desuments and Cattle and	Dooldon)NONE	V 00 Ponc #750 0
2		INL		Documents and Settings\mgq\	Desktop\NGNP\F	1 09 Report\750 C F
3	HYPROTECH	Calgary, Alberta CANADA	Unit Set: NG	BNP		
5	pr-		Date/Time: We	ed May 12 10:51:54 2010		
7	Workh	ook: Case (Ma	in) (continued	n		
8	***************************************	oom ouco (me	iii, (ooniiiidoo	-,		
9 10			Unit Ops (continue	d)		
11	Operation Name	Operation Type	Feeds	Products	Ignored	Calc. Level
12	T20	Tee		Hydrogen Recycle	No	500.0 *
13 14	T1	Tee	1	6	No	500.0 *
15 16	T2	Tee	8	To SG1 To SG 2	No	500.0 *
17	Sweep Hi Temp Recup	Heat Exchanger	28	29	No	500.0 *
18 19	pp	,,,,,,,	Sweep Gas/O2 Out 15	30 16	1	
20	Hi Temp Steam/H2 Recup	Heat Exchanger	H2/Steam	17	No	500.0 *
21	M12	Mixer	14	15	No	500.0 °
22	IVITZ	IVIIXEI	24		No	500.0
23 24	M3	Mixer	11 22	12	No	500.0 *
25	M4	Mixer	25	26	No	500.0 *
26 27			34	4		
28	M1	Mixer	7	-	No	500.0 *
29 30	M2	Mixer	From SG2 From SG 1	9	No	500.0 *
31	Recirc	Compressor	Hydrogen Recycle	23	No	500.0 *
33			Recirc Power 4	5		
34	Circ1	Compressor	Circ1 Pwr		No	500.0
35 36	Circ2	Compressor	9 Circ2 Pwr	10	No	500.0 *
37 38	Low Temp Steam/H2 Recup	LNG	12 17	13 18	No	500.0 *
39			1/ To SG1	From SG 1		
40	SG1	LNG	27	28	No	500.0 *
41	SG2	LNG	13	14	No	500.0 *
42		2.10	To SG 2	From SG2	,,,,	000.0
43 44	Sweep Low Temp Recup	LNG	26 30	27 31	No	500.0 *
45	ILIV	ING	10	8	NI-	500.01
46	IHX	LNG	6	7	No	500.0 *
47 48	Water Pump	Pump	Water In	11	No	500.0 *
49		_	Water Pump Power 20	21		
50	Water Recycle Pump	Pump	Water Recycle Pump Power		No	500.0 *
51 52	Sweep Pump	Pump	Sweep Water In Sweep Pump Power	25	No	500.0 *
53 54	Sweep Water Recycle Pump	Pump	32 Sun Boy Bron Bur	33	No	500.0 *
54 55	- 1		Swp Rcy Pmp Pwr 18	20		
56	Water Separation Tank	Separator	Ambient Cooling	19	No	500.0 *
57 58			24	Ambient Cooling		
59	Water/Oxygen Seperation T	Separator	31 Ambient Cooling 2	32 Oxygen Product	No	500.0 °
60 61	RCY-1	Recycle	23	Ambient Cooling 2	No	3500 °
62	RCY-2	Recycle	21	22	No	3500 *
63	RCY-3	Recycle	33	34	No	3500 *
64	SET-1	Set			No	500.0 °
65	SET-2	Set	LIVOVO BL. L. T.		No	500.0 *
66	Hyprotech Ltd.		HYSYS.Plant v2.2.2 (Build 3	3806)		Page 6 of 22

_									
1	Day.			Case Name:	C:\Documents and Se	ttings\mgq\Desktop\N	GNP\FY 09 Report\750 C I		
2 3 4 5	HY	PROTECH	INL Calgary, Alberta	Unit Set:	NGNP				
4			CANADA	Date/Time:	Date/Time: Wed May 12 10:51:54 2010				
6					•				
7 8		Workb	ook: Case (Ma	ain) (continu	ed)				
9 10				Unit Ops (conti	nued)				
11	Оре	ration Name	Operation Type	Feeds	Product	s Ignore	ed Calc. Level		
12	SET-3		Set			No	500.0 *		
13 14	ADJ-1 ADJ-2		Adjust			No	3500 °		
15	ADJ-2		Adjust			No	3500		
16 17		Sprea	dsheet: Effici	ency			Units Set: NGNP		
18 19				CONNECTIO	NS				
20 21				Imported Varia	bles				
22	Cell		Object		Variable Description		Value		
	B1		m: Reactor Heat	Heat Flow			6.000e+005 kW		
23 24 25	B2		m: Electric Power Out	Power			2.489e+005 kW		
25	B3		m: Circ1 Pwr	Power			1.128e+004 kW		
26 27	B4 B5		m: Electrolysis Power	Power			-2.264e+005 kW		
28	B6	Energy Strea	m: Recirc Power m: Water Pump Power	Power Power			41.70 kW 115.7 kW		
29	B7	Energy Strea		Power			6.343e-002 kW		
30	B8	Energy Strea					6.507 kW		
31	B9	Energy Strea		Power			6.520 kW		
32	D1		m: Ambient Cooling	Heat Flow			-1.203e+004 kW		
33	D2	Energy Strea	m: Ambient Cooling 2	Heat Flow			-1.897e+004 kW		
34	D7	Material Strea	-	Mass Higher Heating Va	lue		1.393e+005 kJ/kg		
35	D8	Material Strea	m: Hydrogen Product	Mass Flow			1.8518 kg/s		
36	D9	Energy Strea	m: Sweep Gas Top Heat	Heat Flow			399.4 kW		
37	D10	Energy Strea	· · · · · · · · · · · · · · · · · · ·	Heat Flow			2752 kW		
38 39	F2	Energy Strea		Power			1531 kW		
39	F3	Te	e: T1	Flow Ratio (Flow Ratio_	1)		0.8958		
40 41 42 43				rted Variables' For					
42	Cell		Object		Variable Description		Value		
43				PARAMETER	RS				
44 45 46				Exportable Vari	ables				
47	Cell	Vi	sible Name	Variable De	scription	Variable Type	Value		
48	B10	B10: Total Electric		Total Electrical Power		Power	0.6194 kW		
49	D3	D3:				Energy	3.100e+004 kW		
50	D4	D4:				Energy	139.5 kW		
51	D5	D5:				_	0.9600		
52	D6	D6:				Power	-2.358e+005 kW		
53	F1	F1: Hydrogen Pro	duction Efficiency	Hydrogen Production Ef	riciency	Percent	42.77		
54	F4 F5	F4:				Power	2.388e+005 kW		
58	F6	F5: F6:				Energy Percent	5.375e+005 kW 44.43		
57	. 0			User Variabl	P6	. STOCIA	11.10		
53 54 55 56 57 58				FORMULAS					
60 61	Cell			Formula	· 		Result		
62	B10	=B2-B3+D6-B5-B	3-B7-B8-B9-D4-F2				0.6194 kW		
63	D3	=-D1-D2				3.100e+004 kW			
64	D4		D3- 0.000092174537				139.5 kW		
65	D6	=B4/D5					-2.358e+005 kW		
66	Hyprote	ch Ltd.		HYSYS.Plant v2.2.2 (B	uild 3806)		Page 7 of 22		

1								
2			INL		Case Nam	e: C:\Documents and	Settings\mgq\Desktop\NG	NP\FY 09 Report\750 C I
3			Calgary, Alberta CANADA		Unit Set:	NGNP		
5	par.				Date/Time:	Wed May 12 10:51	1:54 2010	
6		Spread	dsheet: Effic	riency	Icont	inued)		Inits Set: NGNP
8		Opread	asneet. Line	ленсу	(COIII	iiiueu,		ANTO GET. NOW
9 10					FORMU	LAS		
11	Cel	=(D7*D8)/(B1+D9+		F	ormula			Result
12 13	F1 F4		42.77 2.388e+005 kW					
14	F5		5.375e+005 kW					
15	F6		44.43					
16 17					Spreads	heet		
18		Α	В		<u> </u>	D	Е	F
19	1	Reactor Heat *	6.000e+005 kW *	Ambie	ent Cooling *	-1.203e+004 kW	n Production Efficiency *	42.77
20	2	Electric Power Out *	2.489e+005 kW		t Cooling 2 *	-1.897e+004 kW	Circ 2 Pwr *	1531 kW
21	3	Circ Pwr *	1.128e+004 kW		ent Cooling *	3.100e+004 kW	Flow to Power Cycle *	0.8958
22	4	DC Electrolysis Power *	-2.264e+005 kW	Power to An		139.5 kW	to Electrolysis Process *	2.388e+005 kW
23 24	5	Recirc Pwr *	41.70 kW		conversion *	0.9600	Heat to Power Cycle	5.375e+005 kW
24 25		Water Pump Power	115.7 kW		ysis Power *	-2.358e+005 kW	Power Cycle Efficiency *	44.43
26	7 8	Sweep Pump Pwr * Recycle Pmp Pwr *	6.343e-002 kVV 6.507 kW		H2 Product *	1.393e+005 kJ/kg		
27		weep Rcycl Pump Pwr		eep Gas To	V Hydrogen *	1.8518 kg/s 399.4 kW		
28	10	Total Electrical Power	0.6194 kW		pping Heat *	2752 kW		
29	,,,,							
30 31		Spread	dsheet: Elec	trolys	is Inp	ut and Out	out ^u	Inits Set: Electrolysis
32 33				c	CONNECT	IONS		
34 35				lm	ported Va	ariables		
36	Cel	I	Object			Variable Description		Value
37	B6	Conversion Reacto	r: Isothermal Electrolysis	s @ Act. %	Conversion (Act. % Conversion_1)		66.67
38 39			Ex	ported Va	ariables' l	Formula Results		
40	Ce	I	Object			Variable Description		Value
41 42				ı	PARAMET	TERS		
43 44				Exp	ortable V	ariables .		
45	Ce	l Vis	ible Name		Variable	Description	Variable Type	Value
46 47	A6		n	Steam I	Utilization		Percent	66.67
47	B1							<empty></empty>
48 49	B2		5		of Cells			1.119e+006
49 50	B3 B4		/ (AmnarastaAC)	Cell Are		n ara a famA2\	Small Area	225.0 cm2
5U 51	B4 B5				Density (Am 1100 K (ohn	,		0.6989 0.2776
	B7		(viille viii 2)	701/ @	, roo k (onn	10 VIII 2/		<empty></empty>
53		, 5				-1-1	1	- sinpey-
54					User Vari	abies		
52 53 54 55 56 57					FORMUI	LAS		
57 Cell Formula Res								
57 58	A6				ormula			Result 66.67
59		-60			Spreade	hoot		00.07
60					Spreads		1	
61 62		A	B			D		
63	1 2	Number of Cells *	<empty> * 1.119e+006 *</empty>					
64	3	Cell Area	1.119e+006 ° 225.0 cm2 °					
65		ensity (Amperes/cm^2)	0.6989					
66	_	rotech Ltd.	0.0000	HYSYS	Plant v2.2.2	2 (Build 3806)		Page 8 of 22
_		d to: INI				,		T Specified by user

1	_									
2		INL			Case Name:	C:\Docur	ments and Setti	ngs\mgq\E	Desktop\NGNF	NFY 09 Report\750 C H
3	HYPROTECH	Calgary, A	lberta		Unit Set:	NGNP				
4		CANADA			Date/Time:	Wed Ma	y 12 10:51:54 2	2010		
5					Duter Time.	vvca ma	, 12 10.01.012	.0.0		
7	Sprea	dshee	et: Electr	oly	sis Input	and	Output	t (co	ntin Uni	ts Set: Electrolysis
9					Spreadsheet					
10 11	5 2 1100 K (ohms*cm^2)		0.2776 *							
12	6 66.67		66.67							
13	7		<empty> *</empty>							
14	8									
15	9									
16 17	10									
18 19	Workb	ook:	High Ten	npe	rature Ele	ctro	lysis (T	PL1)	
20 21					Streams					
22	Name		Process In @TPI	_	Sweep Gas In @TPL	Catho	de @TPL1	Sweep	Gas/O2 Out (Gas Products @TPL
23	Vapour Fraction		1.000		1.0000		1.0000		1.0000	1.0000
24 25	Temperature Pressure	(C)	800.0 5.000		800.00 5.0000		800.00 * 5.0000		800.00 5.0000	800.00 5.0000
26		(MPa) kgmole/s)	1.520		0.45611		1.5200		0.91209	1.9760
27	Mass Flow	(kg/s)	24.9		8.2178		10.360		22.809	24.951
28	Liquid Volume Flow	(m3/h)	104	.7	29.64		140.2		75.81	186.3
29	Heat Flow	(kW)	-2.870e+00		-9.687e+004		-7.230e+004		.525e+004	-6.075e+004
30		J/kgmole)	-1.888e+00		-2.124e+005		-4.757e+004		.346e+004	-3.075e+004
31 32	Name Vapour Fraction		Liquid Products (0.000		Anode @TPL1 1.0000	Molar	Flow of Oxyger	Electroly	ysis Heating (Electrode Heat @TPI
33	Temperature	(C)	800.0		804.96					
34	Pressure	(MPa)	5.000		5.0000					
35	Molar Flow (I	kgmole/s)	0.000	00	0.45598		0.45598			
36	Mass Flow	(kg/s)	0.0000		14.591		14.591			
37 38	Liquid Volume Flow Heat Flow	(m3/h)	0.000		46.17 1.162e+004		46.17		.263e+005	75.07
39		(kW) J/kgmole)	-2.975e+0		2.549e+004				203e+005	75.07
40	Name	onigoro/	Process Heat @	_	Electrolysis Power @					
41	Vapour Fraction			-						
42	Temperature	(C)								
43	Pressure	(MPa)		-						
44 45	Molar Flow (I Mass Flow	kgmole/s) (kg/s)								
46	Liquid Volume Flow	(m3/h)								
47	Heat Flow	(kW)	2.384e-00)4	-2.264e+005					
48	Molar Enthalpy (k	J/kgmole)								
49 50					Unit Ops					
5U 51	Operation Name	Ope	ration Type		Feeds		Products		Ignored	Calc. Level
52	- p =	- Ope		Proce	ess In @TPL1	Liqu	uid Products @	TPL1	.9.10104	52.5. 25751
53	Isothermal Electrolysis @TP	Conversi	on Reactor	Elect	rolysis Heating @TF	L1 Gas	s Products @TF	PL1	No	500.0 *
53 54 55 56 57					10-1-1-0		ctrolysis Heatin			+
55 56	MIX-100 @TDL 1	Miyer			d Products @TPL1	Sw	eep Gas/O2 Ou	t @TPL1	Ne	500.0
57	MIX-100 @TPL1	Mixer			e @TPL1 ep Gas In @TPL1				No	500.0
58		_			Products @TPL1	Cat	hode @TPL1			
58 59	Electrodes @TPL1	· ·	nt Splitter		rode Heat @TPL1		de @TPL1		No	500.0 *
60	Gas Product Temperature @								No	500.0 *
61 62	Outlet Pressure @TPL1	Set Set				+			No No	500.0 °
63	Outlet Pressure @TPL1 Inlet Temperature @TPL1	Set				+			No	500.0
64	High Temperature Electrolys		eet						No	500.0
65	Temp Average ASR @TPL1	Spreadsh	eet						No	500.0 °
66	Hyprotech Ltd.			HYSY	S.Plant v2.2.2 (Bui	d 3806)				Page 9 of 22

1	-										
2			INL	Case Name: C:\Documents and S	Settings\mgq\Deskto	p\NGNP\FY 09 Report\750 C I					
3	HY	FROTECH	Calgary, Alberta CANADA	Unit Set: NGNP							
5			5/11/15/1	Date/Time: Wed May 12 10:51:	54 2010						
6		\A/ =l-l=	a a les I Bada Tas		(TDL 4) (-	a 4 (all)					
8		workb	ook: High Ter	nperature Electrolysis	(TPL1) (C	ontinued)					
9				Unit Ops (continued)							
11	Ope	eration Name	Operation Type	Feeds Produc	ets Iq	nored Calc. Level					
12	ADJ-1@	TPL1	Adjust			No 3500 °					
13 14	ADJ-2@	TPL1	Adjust			No 3500 °					
15		Sprea	dsheet: High	Temperature Electrolys	sis @TPL	1 Units Set: Electrolysis					
16	Spreadsheet: High Temperature Electrolysis @TPL1 Units Set: Electrolysis.										
18				CONNECTIONS							
19 20				Imported Variables							
21	Cell		Object	Variable Description		Value					
22 23	D2		m: Process In @TPL1	Temperature		1073.1 K					
24	D3 A8	Material Strea	m: Cathode @TPL1	Temperature Pressure		1073.1 K 5.0000e+006 N/m2					
25	E2	Material Strea		Comp Mole Frac (H2O)		0.90000					
26	F2	Material Strea	m: Process In @TPL1	Comp Mole Frac (Hydrogen)		0.10000					
27	G2	Material Strea		Comp Mole Frac (Oxygen)		0.00014					
28 29	E3		m: Cathode @TPL1	Comp Mole Frac (H2O)		0.30000					
30	F3 G3	Material Strea Material Strea		Comp Mole Frac (Hydrogen) Comp Mole Frac (Oxygen)		0.70000 0.49999					
31	B11	SpreadSheetC		B2: Number of Cells		1.119e+006					
32	B12	SpreadSheetC		B3: Cell Area		225.0 cm2					
33	B13	SpreadSheetC		B4: Current Density (Amperes/cm^2)	0.6989						
34	B16	SpreadSheetC			0.4000						
35 36	D11 D12	Energy Strea Energy Strea		Heat Flow	2.263e+005 kW 75.07 kW						
37 38				rted Variables' Formula Results		,					
39	Cell		Object	Variable Description		Value					
40	B15	Molar Flow of Oxy		Molar Flow		455.98 gmole/s					
41 42	B19	Electrolysis Powe		Power		-2.264e+005 kW					
43	B20	Process Heat @T	PLI	Heat Flow		2.384e-004 kVV					
44				PARAMETERS							
45 46				Exportable Variables							
47	Cell	Vi	isible Name	Variable Description	Variable Type	Value					
48	A1	A1: A1 for Gibbs F		A1 for Gibbs Formation Energy	Gibbs. Coeff. CA						
49 50	A2 A3	A2: A2 for Gibbs F A3: A3 for Gibbs F		A2 for Gibbs Formation Energy	Gibbs, Coeff, CB	39.95 J/gmole-K 3.319e-003 kJ/gmol-K					
51	A3 A4		Formation Energy	A3 for Gibbs Formation Energy A4 for Gibbs Formation Energy (kJ/gmol-K^3)	Gibbs. Coeff. CC	-3.532e-008					
52	A5	A5: A5 for Gibbs F		A5 for Gibbs Formation Energy	Gibbs. Coeff. CB						
53	A6		Number (J/Volt-gmole)	Fa Faraday Number (J/Volt-gmole)		9.649e+004					
54	A7	A7: R Universal G		R Universal Gas Constant	Entropy	8.314 J/gmole-K					
55 56	A9 B14	A9: Standard Pres B14:	ssure	Standard Pressure	Pressure 	1.0132e+005 N/m2 157.2					
57	B15	B15: Molar Flow		Molar Flow	Flow	455.98 gmole/s					
	B17	B17:				1.007					
58 59 60 61	B18	B18:		_		1.286					
60	B19 B20	B19: Power		Power Heat Flow	Power	-2.264e+005 kW					
62	D4	B20: Heat Flow D4:		neat r'IOW	Energy Temperature	2.384e-004 kW 1.5557e-003 K					
63	D6	D6:			Temperature	1073.1 K					
64	D8	D8:				3.501e-007					
65	D9	D9:				-2.251e-004					
66	Hyprote			HYSYS.Plant v2.2.2 (Build 3806)		Page 10 of 22					

1	Dr.		Case Name:	C:\Documents an	d Settings\mgq\Desktop\N	GNP\FY 09 Report\750 C
3	HY	INL Calgary, Alberta	Unit Set:	NGNP		
4	100	CANADA	Date/Time:	Wed May 12 10:	51:54 2010	
5 6						
7		Spreadsheet: High Te	mperature	e Electrol	ysis @TPL1	Units Set: Electrolysis
9 10			PARAMETE	RS		
11 12		E	xportable Var	iables		
13	Cell	Visible Name	Variable De	escription	Variable Type	Value
14	E4	E4:			Vapour Fraction	-0.6000
15	E5	E5:			Vapour Fraction	0.3336
16 17	F4 F5	F4:			Vapour Fraction	0.6000
18	G4	F5: G4:			Vapour Fraction	-0.6194 0.4999
19	G5	G5:			Vapour Fraction Vapour Fraction	-0.8452
20	H2	H2:				6.803e-003
21	H3	H3:				24.67
22	H4	H4:				24.67
23	H5	H5:				54.46
24	12	12:			Molar Enthalpy	1.887e+005 J/gmole
25	13	13:			Molar Enthalpy	1.887e+005 J/gmole
26	16	16:			Molar Enthalpy	1.887e+005 J/gmole
27	J2	J2:			Entropy	2.321e+008 J/gmole-l
28	J3	J3:			Entropy	2.321e+008 J/gmole-l
29	K2	K2:				0.7607
30	K3	K3:				1.091
31	K6	K6:			Vapour Fraction	1.0067
32	K7	K7:				1.007
33 34			User Variab	les		
35 36			FORMULA	s		
37	Cell		Formula			Result
38	B14	=B12*B13				157.2
39	B15	=B11*B14/(4*A6)				455.98 gmole/s
40	B17	@IF(@ABS(D4)<1e-3,K6,K7)				1.007
41	B18	=B17+B13*B16				1.286
42	B19	=-B11*B18*B14/1000				-2.264e+005 kW
43	B20	=B19+D11+D12				2.384e-004 kW
44	D4	=D2-D3				1.5557e-003 K
45	D6	=(D2+D3)/2				1073.1 K
46 47	D8	=1/(2*A6*H4*F4)				3.501e-007
_	D9	=-1/(2*A6*H4*F4*D4)				-2.251e-004
48 49	E4 E5	=E3-E2				-0.6000
49 50	F4	=(E3*@LN(E3)-E3) - (E2*@LN(E2)-E2) =F3-F2				0.3336 0.6000
51	F5	=r3-r2 =(F3*@LN(F3)-F3) - (F2*@LN(F2)-F2)				-0.6194
52	G4	=G3-G2				0.4999
53	G5	=(G3*@LN(G3)-G3) - (G2*@LN(G2)-G2)				-0.8452
54	H2	=G2*A8/A9				6.803e-003
55	НЗ	=G3*A8/A9				24.67
56	H4	=H3-H2				24.67
57	H5	=(H3*@LN(H3)-H3) - (H2*@LN(H2)-H2)				54.46
58	12	=A1 + A2*D2+ A3*D2*2 + A4*D2*3 + A5*D2*@LN(D2)			1.887e+005 J/gmole
59	13	=A1 + A2*D3+ A3*D3^2 + A4*D3^3 + A5*D3*@LN(D3	,			1.887e+005 J/gmole
60	16	=A1 + A2*D6+ A3*D6^2 + A4*D6^3 + A5*D6*@LN(D6	,			1.887e+005 J/gmole
61	J2	= A1*D2 + A2/2*D2*2 + A3/3*D2*3 + A4/4*D2*4 + A5				2.321e+008 J/gmole-l
62	J3	= A1*D3 + A2/2*D3^2 + A3/3*D3^3 + A4/4*D3^4 + A5/	/2*D3^2*(@LN(D3)-	0.5)		2.321e+008 J/gmole-l
63	K2	=1/(2*A6)*(I2-A7*D2*@LN(E2/(F2*H2*0.5)))				0.7607
64	K3	=1/(2*A6)*(I3-A7*D3*@LN(E3/(F3*H3*0.5)))				1.091
35	K6 Hyprote	=D8*(I6*F4*H4 + A7*D6*((E5+F5)*H4 + H5/2*F4))	SYS.Plant v2.2.2 (B			1.0067 Page 11 of 22

Callagry, Aberta CANADA	1	_			Case Nam	e: C:\Documente and S	Settings\mag\Deckton\NG	NDEV 00 Report\750 C
CANADA	2						settingsvingqtDesktopvivo	SIVELET OS REPORTIZO CI
Spreadsheet: High Temperature Electrolysis @TPL1 Units Set: Electrolysis Communication C	4		HYPROTECH					
Spreadsheet: High Temperature Electrolysis @TPL1 Units Set: Electrolysis Spreadsheet: Formula Set Se	5	Br			Date/Time	: Wed May 12 10:51:	54 2010	
	6 7		Spread	dehoot: High	Temperati	ire Electrolys	eie @TDI 1	Inite Set: Electrolysis
	8		Opical	usileet. Tilgi	i remperati	ile Electrolys	sis WIFEI	Jillis Set. Electrolysis
					FORMU	LAS		
Sample S	\blacksquare	Сє	·II		Formula			Result
	\rightarrow	K	7 =D9*(A7/2*(D3^2-E)2^2)*((E5+F5)*H4 + H5/2*	*F4) + F4*H4*(J3-J2))			1.007
1					Spreads	heet		
19	\rightarrow		Α	В	С	D	E	F
3 3 99-003 kJ/gmole**\text{2*} bibs Formation Energy:	\blacksquare							
19	-							
1	\blacksquare							
21 6	\blacksquare					1.5557e-003 K		
22					-		0.3336	-0.6194
Second S	_				Average *	1073.1 K		
Name			7					
1								
Number of Cells 1.119e+006 Electrolysis Heating 2.283e+005 kW			1.0132e+005 N/m2 *	Standard Pressure *	C average *	-2.251e-004		
Second S	-		Normalian - CO-P	4.440000-	Electrolysis Heathers	2 202 - 1025 1441		
1	20							
Molar Flow of Oxygen					Electrode Heat	75.U7 KVV		
Molar Flow of Coygen 455.98 gmole/s 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000 0.4000								
16								
17								
18								
19								
	-							
G	-							
1	36		G	Н	ı	J	K	
Second Company Compa	37	1	y O2 *		Delta G *	Integral Delta G dT *	Nernst Voltage *	
	38	2	0.00014		1.887e+005 J/gmole	2.321e+008 J/gmole-K	0.7607	
S		3	0.49999	24.67	1.887e+005 J/gmole	2.321e+008 J/gmole-K	1.091	
1.887e+005 J/gmole			0.4999	24.67				
Average 1.007			-0.8452	54.46				
44					1.887e+005 J/gmole	Isothermal *	1.0067	
SpreadSheet: Temp Average ASR @TPL1	43					Average *	1.007	
46								
11	45							
12	46							
13								
14								
15								
16	$\boldsymbol{\vdash}$							
17	-							
18	$\overline{}$							
Spreadsheet: Temp Average ASR @TPL1	\blacksquare							
Spreadsheet: Temp Average ASR @TPL1 Units Set: Electrolysis, CONNECTIONS Convert Convert	_							
Spreadsheet: Temp Average ASR @TPL1	_							
CONNECTIONS CONNECTIONS CONNECTIONS CONNECTION	\rightarrow							
CONNECTIONS	_		Spread	dsheet: Tem	p Average A	ASR @TPL1		Units Set: Electrolysis
Imported Variables	\blacksquare				CONNECT	TIONS		
64 Cell Object Variable Description Value 65 B1 SpreadSheetCell: Electrolysis Input and O B5: ASR @ 1100 K (ohms*cm^2) 0.2776	62				Imported Va	ariables		
	64	Ce	:II	Object		Variable Description		Value
	65	B'	SpreadSheetCe	II: Electrolysis Input and	O B5: ASR @ 1100 K	(ohms*cm^2)		0.2776
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1					
2	No.	INL	Case Name: C:\Documents	and Settings\mgq\Desktop\N0	3NP\FY 09 Report\750 C F
3	HY	Calgary, Alberta CANADA	Unit Set: NGNP		
5		CARADA	Date/Time: Wed May 12 1	0:51:54 2010	
6					
8		Spreadsheet: Temp	Average ASR @TPL	_1 (continued	Units Set: Electrolysis
9 10			CONNECTIONS		
11 12			Imported Variables		
13	Cell	Object	Variable Descrip	tion	Value
14	A3	Material Stream: Process In @TPL1	Temperature		1073.1 K
15 16	E15	Material Stream: Cathode @TPL1	Temperature		1073.1 K
17		Expo	rted Variables' Formula Result	s	
18	Cell	Object	Variable Descrip	tion	Value
19			PARAMETERS		
20 21					
22			Exportable Variables		
23	Cell	Visible Name	Variable Description	Variable Type	Value
24	A4	A4:		Temperature	1073.1 K
25	A5	A5:		Temperature	1073.1 K
26 27	A6 A7	A6: A7:		Temperature Temperature	1073.1 K 1073.1 K
28	A8	A8:		Temperature	1073.1 K
29	A9	A9:		Temperature	1073.1 K
30	A10	A10:		Temperature	1073.1 K
31	A11	A11:		Temperature	1073.1 K
32	A12	A12:		Temperature	1073.1 K
33	A13	A13:		Temperature	1073.1 K
34 35	A14	A14: A15:		Temperature	1073.1 K
36	A15 A16	A16:		Temperature Temperature	1073.1 K 1073.1 K
37	A17	A17:		Temperature	1073.1 K
38	A18	A18:		Temperature	1073.1 K
39	A19	A19:		Temperature	1073.1 K
40	A20	A20:			40.00
41	B2	B2: Temp Aver ASR	Temp Aver ASR		0.4000
42 43	B3 B4	B3: B4:			0.4000 0.4000
44	B5	B5:			0.4000
45	B6	B6:			0.4000
46	B7	B7:			0.4000
47	B8	B8:			0.4000
48	B9	B9:			0.4000
49	B10	B10:			0.4000
51	B11 B12	B11: B12:			0.4000 0.4000
52	B13	B13:			0.4000
53	B14	B14:			0.4000
54	B15	B15:			0.4000
55	B16	B16:			0.4000
56 57	B17	B17:			0.4000
58	B18 B19	B18: B19:			0.4000 0.4000
59	B20	B20:			19.20
60	C1	C1:		Temperature	1073.1 K
61	C2	C2:		Temperature	1073.1 K
62	C3	C3:		Temperature	1073.1 K
63	C4	C4:		Temperature	1073.1 K
64 65	C5 C6	C5: C6:		Temperature	1073.1 K
66	Hyprote		HYSYS.Plant v2.2.2 (Build 3806)	Temperature	1073.1 K Page 13 of 22
~	riyprote	VII EW.	11101011 MIN 72.2.2 (Dulid 5000)		1 age 10 01 22

Hyprotech Ltd. Hysys.Plant v2.2.2 (Build 3806) Page 13 of 2:

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1	h		Case Name: C:\Documents and	Settings\mga\Deskton\N	GNP\FY 09 Report\750 C I
2		INL		Cettings ang que est to par	5141 11 1 05 Reporti/ 50 0 1
3	HY	Calgary, Alberta CANADA	Unit Set: NGNP		
5	Bearing	5/40/6/	Date/Time: Wed May 12 10:51	:54 2010	
6 7		Spreadsheet: Temp A	verage ASR @TPL1	(continue)	Units Set: Electrolysis
8		oproduction remp /		(John Hart	
10			PARAMETERS		
11 12			Exportable Variables		
13	Cell	Visible Name	Variable Description	Variable Type	Value
14	C7	C7:		Temperature	1073.1 K
15	C8	C8:		Temperature	1073.1 K
16 17	C9 C10	C9:		Temperature	1073.1 K
18	C10	C10: C11:		Temperature	1073.1 K 1073.1 K
19	C12	C12:		Temperature Temperature	1073.1 K
20	C13	C13:		Temperature	1073.1 K
21	C14	C14:		Temperature	1073.1 K
22	C15	C15:		Temperature	1073.1 K
23	C16	C16:		Temperature	1073.1 K
24	C17	C17:		Temperature	1073.1 K
25	C18	C18:		Temperature	1073.1 K
26	C19	C19:		Temperature	1073.1 K
27	D1	D1:			0.4000
28	D2	D2:			0.4000
29	D3	D3:			0.4000
30	D4	D4:			0.4000
31	D5	D5:			0.4000
32	D6	D6:			0.4000
33	D7	D7:			0.4000
34	D8	D8:			0.4000
35	D9	D9:			0.4000
36	D10	D10:			0.4000
37 38	D11	D11:			0.4000
38	D12	D12:			0.4000
40	D13 D14	D13:			0.4000
41	D14	D14: D15:			0.4000 0.4000
42	D16	D16:			0.4000
43	D17	D17:			0.4000
44	D18	D18:			0.4000
45	D19	D19:			0.4000
46	E1	E1:		Temperature	1073.1 K
47	E2	E2:		Temperature	1073.1 K
48	E3	E3:		Temperature	1073.1 K
49	E4	E4:		Temperature	1073.1 K
50	E5	E5:		Temperature	1073.1 K
51	E6	E6:		Temperature	1073.1 K
52	E7	E7:		Temperature	1073.1 K
53	E8	E8:		Temperature	1073.1 K
54	E9	E9:		Temperature	1073.1 K
55	E10	E10:		Temperature	1073.1 K
56 57	E11	E11:		Temperature	1073.1 K
57 58	E12	E12:		Temperature	1073.1 K
58	E13 E14	E13: E14:		Temperature Temperature	1073.1 K
60	F1	F1:			1073.1 K 0.4000
61	F2	F2:			0.4000
62	F3	F3:			0.4000
63	F4	F4:			0.4000
64	F5	F5:			0.4000
65	F6	F6:			0.4000
66	Hyprote		(SYS.Plant v2.2.2 (Build 3806)	•	Page 14 of 22
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* Specified by user.

1			0.0	0.41.	ID-51/ 00 D - 47550 O
2		INL		Settings\mgq\Desktop\NG\	IPIFY 09 Report/750 C r
2 3 4 5	HY	Calgary, Alberta CANADA	Unit Set: NGNP		
	part of the same o		Date/Time: Wed May 12 10:51	:54 2010	
6 7 8		Spreadsheet: Temp Ave	erage ASR @TPL1	(continued u	nits Set: Electrolysis
9			PARAMETERS		
11		Exp	oortable Variables		
13	Cell	Visible Name	Variable Description	Variable Type	Value
14	F7	F7:			0.4000
15	F8	F8:			0.4000
16 17	F9	F9:			0.4000
18	F10 F11	F10:			0.4000
19	F12	F11: F12:			0.4000 0.4000
20	F13	F13:			0.4000
21	F14	F14:			0.4000
22	F15	F15:			0.4000
	F16	F16:		Temperature	-3.1114e-005 K
23 24 25				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
25			User Variables		
26			FORMULAC		
27			FORMULAS		
28	Cell	F	ormula		Result
29	A4	=A3+F16			1073.1 K
30	A5	=A4+F16			1073.1 K
31	A6	=A5+F16			1073.1 K
32	A7	=A6+F16			1073.1 K
33	A8	=A7+F16			1073.1 K
34 35	A9	=A8+F16			1073.1 K
36	A10	=A9+F16			1073.1 K
37	A11 A12	=A10+F16 =A11+F18			1073.1 K 1073.1 K
38	A13	=A12+F16			1073.1 K
38 39	A14	=A13+F16			1073.1 K
40	A15	=A14+F16			1073.1 K
40 41 42 43 44	A16	=A15+F16			1073.1 K
42	A17	=A16+F16			1073.1 K
43	A18	=A17+F16			1073.1 K
44	A19	=A18+F16			1073.1 K
45	A20	=4*(B4+B6+B8+B10+B12+B14+B16+B18+D1+D3+D5+	D7+D9+D11+D13+D15+D17+D19+F2	+F4+F6+F8+F10+F12+F1	40.00
46	B2	@if(E15==A3,F15,(1/3*F16*(B3+A20+B20+F15))/(E15-A	A3))		0.4000
47	В3	@EXP(10300/A3)*0.00003973+(B1-0.463)			0.4000
48	B4	@EXP(10300/A4)*0.00003973+(B1-0.463)			0.4000
49	B5	@EXP(10300/A5)*0.00003973+(B1-0.463)			0.4000
50	B6	@EXP(10300/A6)*0.00003973+(B1-0.463)			0.4000
51	B7	@EXP(10300/A7)*0.00003973+(B1-0.463)			0.4000
52	B8	@EXP(10300/A8)*0.00003973+(B1-0.463)			0.4000
53 54 55 56 57 58 59 60 61 62 63	B9	@EXP(10300/A9)*0.00003973+(B1-0.463) @EXP(10300/A10)*0.00003973+(B1-0.463)			0.4000 0.4000
55	B10 B11	@EXP(10300/A10)*0.00003973+(B1-0.463) @EXP(10300/A11)*0.00003973+(B1-0.463)			0.4000
56	B12	@EXP(10300/A11) 0.00003973+(B1-0.463) @EXP(10300/A12)*0.00003973+(B1-0.463)			0.4000
57	B13	@EXP(10300/A12) 0.00003973+(B1-0.403) @EXP(10300/A13)*0.00003973+(B1-0.463)			0.4000
58	B14	@EXP(10300/A14)*0.00003973+(B1-0.463)			0.4000
59	B15	@EXP(10300/A15)*0.00003973+(B1-0.463)			0.4000
60	B16	@EXP(10300/A16)*0.00003973+(B1-0.463)			0.4000
61	B17	@EXP(10300/A17)*0.00003973+(B1-0.463)			0.4000
62	B18	@EXP(10300/A18)*0.00003973+(B1-0.463)			0.4000
63	B19	@EXP(10300/A19)*0.00003973+(B1-0.463)			0.4000
64 65	B20	=2*(B5+B7+B9+B11+B13+B15+B17+B19+D2+D4+D6+	D8+D10+D12+D14+D16+D18+F1+F3	+F5+F7+F9+F11+F13)	19.20
	C1	=A19+F16			1073.1 K
66	Hyprote	ch Ltd. HYSYS	S.Plant v2.2.2 (Build 3806)		Page 15 of 22

1			Case Name: C:\Documents and Settings\mgq\Desktop\N	CNDIEV 00 Paport\750 C
2		INL		SNETE OF REPORTSOC
3	HY	Calgary, Alberta CANADA	Unit Set: NGNP	
5	pr.		Date/Time: Wed May 12 10:51:54 2010	
7 8		Spreadsheet: Temp Ave	erage ASR @TPL1 (continued	Units Set: Electrolysis
9 10			FORMULAS	
11	Cell	F	Formula	Result
12	C2	=C1+F16		1073.1 K
13	C3	=C2+F16		1073.1 K
14 15	C4	=C3+F16		1073.1 K
16	C5 C6	=C4+F16 =C5+F16		1073.1 K 1073.1 K
17	C7	=C6+F16		1073.1 K
18	C8	=C7+F16		1073.1 K
19	C9	=C8+F16		1073.1 K
20	C10	=C9+F16		1073.1 K
21	C11	=C10+F16		1073.1 K
22 23	C12 C13	=C11+F16 =C12+F16		1073.1 K 1073.1 K
24	C14	=C12+F16 =C13+F16		1073.1 K
25	C15	=C14+F16		1073.1 K
26	C16	=C15+F16		1073.1 K
27	C17	=C16+F16		1073.1 K
28	C18	=C17+F16		1073.1 K
29	C19	=C18+F16		1073.1 K
30 31	D1 D2	@EXP(10300/C1)*0.00003973+(B1-0.463) @EXP(10300/C2)*0.00003973+(B1-0.463)		0.4000 0.4000
32	D3	@EXP(10300/C2)*0.00003973+(B1-0.463)		0.4000
33	D4	@EXP(10300/C4)*0.00003973+(B1-0.463)		0.4000
34 35	D5	@EXP(10300/C5)*0.00003973+(B1-0.463)		0.4000
35	D6	@EXP(10300/C6)*0.00003973+(B1-0.463)		0.4000
36 37	D7	@EXP(10300/C7)*0.00003973+(B1-0.463)		0.4000
38	D8 D9	@EXP(10300/C8)*0.00003973+(B1-0.463)		0.4000 0.4000
39	D10	@EXP(10300/C9)*0.00003973+(B1-0.463) @EXP(10300/C10)*0.00003973+(B1-0.463)		0.4000
40	D11	@EXP(10300/C11)*0.00003973+(B1-0.463)		0.4000
40 41	D12	@EXP(10300/C12)*0.00003973+(B1-0.463)		0.4000
42 43	D13	@EXP(10300/C13)*0.00003973+(B1-0.463)		0.4000
43	D14	@EXP(10300/C14)*0.00003973+(B1-0.463)		0.4000
44 45	D15	@EXP(10300/C15)*0.00003973+(B1-0.463)		0.4000
46	D16 D17	@EXP(10300/C16)*0.00003973+(B1-0.463)		0.4000 0.4000
47	D17	@EXP(10300/C17)*0.00003973+(B1-0.463) @EXP(10300/C18)*0.00003973+(B1-0.463)		0.4000
48	D19	@EXP(10300/C19)*0.00003973+(B1-0.463)		0.4000
49	E1	=C19+F16		1073.1 K
50	E2	=E1+F16		1073.1 K
51 52	E3	=E2+F16		1073.1 K
52 53	E4 E5	=E3+F16 =E4+F16		1073.1 K 1073.1 K
54	E6	=E5+F16		1073.1 K
55	E7	=E6+F16		1073.1 K
56	E8	=E7+F16		1073.1 K
57	E9	=E8+F16		1073.1 K
58	E10	=E9+F16		1073.1 K
59 60	E11 E12	=E10+F16 =E11+F16		1073.1 K 1073.1 K
61	E13	=E12+F16		1073.1 K
62	E14	=E13+F16		1073.1 K
63	F1	@EXP(10300/E1)*0.00003973+(B1-0.463)		0.4000
64	F2	@EXP(10300/E2)*0.00003973+(B1-0.463)		0.4000
65	F3	@EXP(10300/E3)*0.00003973+(B1-0.463)	2 Plants 2 0 0 (Puild 2000)	0.4000
66	Hyprote Licensed to:		S.Plant v2.2.2 (Build 3806)	Page 16 of 22 * Specified by user.

1	De.			Case Name:	C:\Documents and	Settings\mag\Deskton\NG	SNP\FY 09 Report\750 C I
2		INL				oethingsungqiDesktopiivo	or a 1 of Reporting C i
3	-		lgary, Alberta NADA	Unit Set:	NGNP		
5	Bar			Date/Time:	Wed May 12 10:51	:54 2010	
7 8		Spreads	heet: Tem	p Average A	SR @TPL1	(continued	Units Set: Electrolysis
9				FORMULA	s		
11	Ce	I		Formula			Result
12	F4	@EXP(10300/E4)*0.0	0003973+(B1-0.463)				0.4000
13	F5						0.4000
14	F6						0.4000
15 16	F7 F8		, ,				0.4000 0.4000
17	F9						0.4000
18	F10		00003973+(B1-0.463)				0.4000
19	F1		00003973+(B1-0.463)				0.4000
20	F12		00003973+(B1-0.463)				0.4000
21	F13		00003973+(B1-0.463)				0.4000
22	F14		00003973+(B1-0.463)				0.4000
23	F1:		00003973+(B1-0.463)				0.4000
24 25	F16	6 =(E15-A3)/50					-3.1114e-005 K
26				Spreadshe	et		
27		Α	В	С	D	Е	F
28	1	ASR @ 1100 K *	0.2776 ⁻	1073.1 K	0.4000	1073.1 K	0.4000
29	2	Temp Average ASR *	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
30	3	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
31 32	4	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
33	5 6	1073.1 K 1073.1 K	0.4000 0.4000	1073.1 K	0.4000 0.4000	1073.1 K 1073.1 K	0.4000 0.4000
34	7	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
35	8	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
36	9	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
37	10	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
38	11	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
39	12	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
40	13	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
41	14	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K	0.4000
42 43	15	1073.1 K	0.4000	1073.1 K	0.4000	1073.1 K *	0.4000
44	16 17	1073.1 K 1073.1 K	0.4000 0.4000	1073.1 K	0.4000 0.4000	delta T *	-3.1114e-005 K
44 45	18	1073.1 K	0.4000	1073.1 K	0.4000		
46	19	1073.1 K	0.4000	1073.1 K	0.4000		
47	20	40.00	19.20				
48 49		Conver	rsion: Elect	rolysis			
50 51				STOICHIOME	TRY		
52 53		Component		Mole Weight		Stoichiome	tric Coeff
54	H20			Wole ##eigili	18.015	Storchiome	-1 *
55		ogen			2.016		1*
56	Оху	-			32.000		0.
57							
58							
59 80		Balance Err	or: 0.0000		React	ion Heat: 2.410e+005 l	(J/kgmole
60 61				BASIS			
62		Base Component: H2O	Co	onversion Percent: 100.0	0 1	Reaction Phase:	VapourPhase
63			, 0.	PARAMETE			
64 65							
65 66	Hvm	rotech Ltd.		HYSYS.Plant v2.2.2 (E	Ruild 3806)		Page 17 of 22
00	пур	Olecti Liu.		111313.Flatil V2.2.2 (t	oulid South		Fage 17 01 22

Licensed to: INL Page 17 of 2

* Specified by user.

1	>			Case Name:	C:\Documents and Setti	ngs/mgg/Deskton/NGNI	2\EV 00 Report\750 C
2		INL Calgary, A	Alberta		NGNP	nga mgqibeaniopi voru	ii i oo kepokii oo o i
4	HYPROTEC	CANADA					
5	P			Date/Time:	Wed May 12 10:51:54 2	2010	
6 7 8	Wor	kbook:	Rankine St	eam Cycle	(TPL2)		
9 10				Material Strean	ns		
11	Name		Steam Generator Out	4 @TPL2	To Reheater @TPL2	To FW Heater 7 @TF	8 @TPL2
12	Vapour Fraction		1.0000	1.0000	1.0000	1.0000	1.0000
13	Temperature	(C)	593.00 *	353.85	353.85	353.85	593.00 °
14	Pressure	(MPa)	24.000	5.4000 *	5.4000	5.4000	4.8600
15	Molar Flow	(kgmole/s)	11.007	11.007	10.446	0.56138	10.446
16	Mass Flow	(kg/s)	198.30	198.30	188.19	10.113	188.19
17	Liquid Volume Flow	(m3/h)	715.3	715.3	678.8	36.48	678.8
18	Heat Flow	(kW)	-2.474e+006	-2.547e+006	-2.417e+006	-1.299e+005	-2.311e+006
19 20	Name Vapour Fraction		10 @TPL2 0.0000	11 @TPL2 0.0000	Steam Generator In (0.0000	17 @TPL2 0.0000	13 @TPL2 1.0000
21	Temperature	(C)	252.09	246.54	265.71	238.98	542.04
22	Pressure	(MPa)	5.2920	27.211 *	26.667	3.2462	3.5800 °
23	Molar Flow	(kgmole/s)	0.56138	11.007	11.007	11.007	10.446
24	Mass Flow	(kg/s)	10.113	198.30	198.30 *	198.30	188.19
25	Liquid Volume Flow	(m3/h)	36.48	715.3	715.3	715.3	678.8
26	Heat Flow	(kW)	-1.496e+005	-2.939e+006	-2.919e+006	-2.946e+006	-2.330e+006
27	Name	1	14 @TPL2	15 @TPL2	16 @TPL2	18 @TPL2	21 @TPL2
28	Vapour Fraction		1.0000	1.0000	0.6759	1.0000	1.0000
29	Temperature	(C)	542.04	542.04	244.73	476.10	476.10
30	Pressure	(MPa)	3.5800	3.5800	3.5800	2.3500 *	2.3500
31	Molar Flow	(kgmole/s)	0.52230	9.9237	1.0837	9.9237	9.4275
32	Mass Flow	(kg/s)	9.4093	178.78	19.523	178.78	169.84
33	Liquid Volume Flow	(m3/h)	33.94	644.9	70.42	644.9	612.7
34	Heat Flow	(kW)	-1.165e+005	-2.214e+006	-2.661e+005	-2.237e+006	-2.125e+006
35	Name		22 @TPL2	20 @TPL2	24 @TPL2	25 @TPL2	26 @TPL2
36 37	Vapour Fraction	(0)	1.0000	0.4026	1.0000	1.0000	1.0000
38	Temperature Pressure	(C)	476.10 2.3500	221.24	386.29	386.29	386.29
39	Molar Flow	(MPa) (kgmole/s)	0.49619	2.3500 1.5799	1.1596 9.4275	1.1596 8.9562	1.1596 0.47138
40	Mass Flow	(kg/lole/s)	8.9388	28.461	169.84	161.35	8.4919
41	Liquid Volume Flow	(m3/h)	32.24	102.7	612.7	582.0	30.63
42	Heat Flow	(kW)	-1.119e+005	-4.040e+005	-2.155e+006	-2.048e+006	-1.078e+005
43	Name	(-11-7)	27 @TPL2	28 @TPL2	35 @TPL2	38 @TPL2	39 @TPL2
44	Vapour Fraction		0.0000	0.0000	0.0000	0.0000	0.0000
45	Temperature	(C)	187.04	219.05	213.50	192.60	158.16
46	Pressure	(MPa)	3.3800 *	3.5084	3.3124	2.3030	1.1596
47	Molar Flow	(kgmole/s)	11.007	1.0837	11.007	1.5799	8.9562
48	Mass Flow	(kg/s)	198.30	19.523	198.30	28.461	161.35
49	Liquid Volume Flow	(m3/h)	715.3	70.42	715.3	102.7	582.0
50	Heat Flow	(kW)	-2.998e+006	-2.921e+005	-2.972e+006	-4.296e+005	-2.461e+006
51	Name		40 @TPL2	41 @TPL2	43 @TPL2	44 @TPL2	45 @TPL2
52	Vapour Fraction	201	0.0000	0.0145	1.0000	1.0000	1.0000
53 54	Temperature	(C)	186.54 1.1596	186.63	318.57	318.57	318.57
55	Pressure Molar Flow	(MPa)		1.1596 1.5799	0.64300 *	0.64300	0.64300 0.44781
56	Mass Flow	(kgmole/s) (kg/s)	11.007 198.30	28.461	8.9562 161.35	8.5084 153.28	8.0673
57	Liquid Volume Flow	(m3/h)	715.3	102.7	582.0	552.9	29.10
58	Heat Flow	(kW)	-2.999e+006	-4.296e+005	-2.069e+006	-1.965e+006	-1.034e+005
59 60 61 62 63 64							
0.6							
00	Hyprotech Ltd.			SYS.Plant v2.2.2 (Buil	14 2000)		Page 18 of 22

1				Case Name:	C:\Documents and Setti	nas/man/Deskton/NGNI	P\FY 09 Report\750 C t
2		INL	NII			nga mgqtDoomtop ii torti	THE TOO TROPORTION OF THE
4	HYPROTEC	Calgary, A	Аlberta		NGNP		
5	-			Date/Time:	Wed May 12 10:51:54 2	2010	
6 7 8	Wor	kbook:	Rankine St	eam Cycle	(TPL2) (coi	ntinued)	
9 10			Mate	rial Streams (co	ntinued)		
11	Name		46 @TPL2	47 @TPL2	48 @TPL2	49 @TPL2	51 @TPL2
12	Vapour Fraction		0.0000	1.0000	0.0000	0.0001	1.0000
13	Temperature	(C)	135.82	246.82	130.26	135.82	246.82
14	Pressure	(MPa)	0.63014	0.32100 *	1.1759	0.32100	0.32100
15 16	Molar Flow	(kgmole/s)	0.44781	8.5084	8.9562	0.44781	8.0829
17	Mass Flow Liquid Volume Flow	(kg/s) (m3/h)	8.0673 29.10	153.28 552.9	161.35 582.0	8.0673 29.10	145.61 525.3
18	Heat Flow	(kW)	-1.239e+005	-1.987e+006	-2.482e+006	-1.239e+005	-1.887e+006
19	Name	(KVV)	52 @TPL2	53 @TPL2	54 @TPL2	55 @TPL2	56 @TPL2
20	Vapour Fraction		1.0000	1.0000	1.0000	1.0000	0.0000
21	Temperature	(C)	246.82	167.46	167.46	167.46	107.38
22	Pressure	(MPa)	0.32100	0.13300 *	0.13300	0.13300	0.31458
23	Molar Flow	(kgmole/s)	0.42542	8.0829	7.2342	0.84871	0.87323
24	Mass Flow	(kg/s)	7.6639	145.61	130.33	15.290	15.731
25	Liquid Volume Flow	(m3/h)	27.65	525.3	470.1	55.15	56.75
26	Heat Flow	(kW)	-9.933e+004	-1.909e+006	-1.709e+006	-2.005e+005	-2.436e+005
27	Name		57 @TPL2	60 @TPL2	62 @TPL2	64 @TPL2	74 @TPL2
28 29	Vapour Fraction		0.0000	0.0000	0.0000	0.9459	0.5177
30	Temperature	(C)	101.83	43.291	37.613 6.7569e-003	38.957	107.75
31	Pressure Molar Flow	(MPa) (kgmole/s)	1.1999 8.9562	0.13034 1.7219	8.9562	6.8948e-003 * 7.2342	0.13300 1.7219
32	Mass Flow	(kg/s)	161.35	31.021	161.35	130.33	31.021
33	Liquid Volume Flow	(m3/h)	582.0	111.9	582.0	470.1	111.9
34	Heat Flow	(kW)	-2.502e+006	-4.890e+005	-2.547e+006	-1.757e+006	-4.441e+005
35	Name		78 @TPL2	34 @TPL2	23 @TPL2	36 @TPL2	37 @TPL2
36	Vapour Fraction		0.0000	0.0224	0.0000	0.5362	0.0000
37	Temperature	(C)	36.257	244.73	219.09	135.82	107.42
38	Pressure	(MPa)	6.7569e-003	3.5800	2.3500	0.32100	0.13300
39	Molar Flow	(kgmole/s)	7.2342	0.56138	1.0837	0.87323	0.87323
40	Mass Flow	(kg/s)	130.33	10.113	19.523	15.731	15.731
41 42	Liquid Volume Flow	(m3/h)	470.1	36.48	70.42	56.75	56.75
43	Heat Flow Name	(kW)	-2.058e+006 58 @TPL2	-1.496e+005 59 @TPL2	-2.921e+005 63 @TPL2	-2.232e+005 79 @TPL2	-2.436e+005 81 @TPL2
44	Vapour Fraction		0.0000	0.0084	1.0000	1.0000	1.0000
45	Temperature	(C)	37.735	38.585	750.00	750.00	291.05
46	Pressure	(MPa)	1.2000 *	6.7569e-003	7.0000	7.0000	6.8600
47	Molar Flow	(kgmole/s)	8.9562	1.7219	46.695	13.751	46.695
48	Mass Flow	(kg/s)	161.35	31.021	186.92	55.045	186.92
49	Liquid Volume Flow	(m3/h)	582.0	111.9	5424	1597	5424
50	Heat Flow	(kW)	-2.547e+006	-4.890e+005	7.070e+005	2.082e+005	2.616e+005
51	Name		82 @TPL2	2 @TPL2	3 @TPL2		
52	Vapour Fraction	/^\	1.0000	1.0000	1.0000		
53 54	Temperature Pressure	(C) (MPa)	378.85 6.8600	750.00 7.0000	311.02 6.8600		
55	Molar Flow	(kgmole/s)	13.751	60.446	60.446		
56	Mass Flow	(kg/liole/s)	55.045	241.97	241.97		
57	Liquid Volume Flow	(m3/h)	1597	7021	7021		
58	Heat Flow	(kW)	1.021e+005	9.152e+005	3.638e+005		
59 60		, , ,		Compositions			
60 61	Name		Steam Generator Out	-	To Reheater @TPL2	To FW Heater 7 @TF	8 @TPL2
62	Comp Mole Frac (H2O)		1.00000 *	1.00000	1.00000	1.00000	1.00000
63	Comp Mole Frac (Heliu	m)	0.00000 *	0.00000	0.00000	0.00000	0.00000
64 65							
66	Hyprotech Ltd.		HYS	SYS.Plant v2.2.2 (Buil	d 3806)		Page 19 of 22
_	Licensed to: INI		- 111.	1000			7 Specified by upon

1					0				NEW 00 B 41750 01
2		INL			Case Name: C	:\Documents and Settir	ngs\mgq\E	Desktop\NGNF	NFY 09 Report\750 C
3	HYPROTECH	Calgary, A	Alberta		Unit Set: N	IGNP			
5	No.	CANADA			Date/Time: V	Ved May 12 10:51:54 2	010		
6 7 8	Workb	ook:	Rankine	Stea	eam Cycle (TPL2) (continued)				
9			(Comp	ositions (conti	inued)			
11	Name		10 @TPL2	11	1 @TPL2	Steam Generator In (17 @TP	1.2	13 @TPL2
12	Comp Mole Frac (H2O)		1.0000	_	1.00000	1.00000		1.00000	1.00000
13	Comp Mole Frac (Helium)		0.0000	00	0.00000	0.00000		0.00000	0.00000
14	Name		14 @TPL2	18	5 @TPL2	16 @TPL2	18 @TP	L2	21 @TPL2
15	Comp Mole Frac (H2O)		1.0000	00	1.00000	1.00000		1.00000	1.00000
16	Comp Mole Frac (Helium)		0.0000		0.00000	0.00000		0.00000	0.00000
17	Name		22 @TPL2		0 @TPL2	24 @TPL2	25 @TP		26 @TPL2
18	Comp Mole Frac (H2O)		1.0000		1.00000	1.00000		1.00000	1.00000
19	Comp Mole Frac (Helium)		0.0000	-	0.00000	0.00000	22.075	0.00000	0.00000
20 21	Name		27 @TPL2		8 @TPL2	35 @TPL2	38 @TP		39 @TPL2
22	Comp Mole Frac (H2O)		0.0000		1.00000 0.00000	1.00000 0.00000		1.00000 0.00000	1.00000 0.00000
23	Comp Mole Frac (Helium) Name			_			44 @TD		45 @TPL2
24	Comp Mole Frac (H2O)		40 @TPL2 1.0000		1 @TPL2 1.00000	43 @TPL2 1.00000	44 @TP	1.00000	45 @TPL2 1.00000
25	Comp Mole Frac (Helium)		0.0000	_	0.00000	0.00000		0.00000	0.00000
26	Name		46 @TPL2		7 @TPL2	48 @TPL2	49 @TP		51 @TPL2
27	Comp Mole Frac (H2O)		1.0000	_	1.00000	1.00000	10 (2) 11	1.00000	1.00000
28	Comp Mole Frac (Helium)		0.0000	_	0.00000	0.00000		0.00000	0.00000
29	Name		52 @TPL2		3 @TPL2	54 @TPL2	55 @TP		56 @TPL2
30	Comp Mole Frac (H2O)		1.0000	_	1.00000	1.00000	** 6	1.00000	1.00000
31	Comp Mole Frac (Helium)		0.0000		0.00000	0.00000		0.00000	0.00000
32	Name		57 @TPL2	60	0 @TPL2	62 @TPL2	64 @TP	L2	74 @TPL2
33	Comp Mole Frac (H2O)		1.0000	00	1.00000	1.00000		1.00000	1.00000
34	Comp Mole Frac (Helium)		0.0000	00	0.00000	0.00000		0.00000	0.00000
35	Name		78 @TPL2	34	4 @TPL2	23 @TPL2	36 @TP	L2	37 @TPL2
36	Comp Mole Frac (H2O)		1.0000	00	1.00000	1.00000		1.00000	1.00000
37	Comp Mole Frac (Helium)		0.0000	00	0.00000	0.00000		0.00000	0.00000
38	Name		58 @TPL2	59	9 @TPL2	63 @TPL2	79 @TP	L2	81 @TPL2
39	Comp Mole Frac (H2O)		1.0000	00	1.00000	0.00000		0.00000	0.00000
40	Comp Mole Frac (Helium)		0.0000	00	0.00000	1.00000		1.00000	1.00000
41	Name		82 @TPL2		@TPL2	3 @TPL2			
42	Comp Mole Frac (H2O)		0.0000	_	0.00000	0.00000			
43	Comp Mole Frac (Helium)		1.0000	00	1.00000	1.00000			
44 45				E	Energy Streams	s			
46	Name		HP Trbn Pwr @TF	PL2 IT	Trbn Stg 1 Pwr @1	ITTrbn Stg 2 Pwr @T		Stg 1 Pwr @T	Bstr Pmp Pwr @TPL:
47	Heat Flow	(kW)	7.286e+00	-	1.946e+004	2.369e+004	2	.998e+004	675.3
48	Name		LP Trbn Stg 2 Pw		P Trbn Stg 3 Pwr @	LP Trbn Stg 4 Pwr @		Stg 5 Pwr @T	Cond Q @TPL2
49	Heat Flow	(kW)	2.129e+00	_	2.119e+004	2.200e+004	4	.837e+004	3.012e+005
50 51	Name	//146	BF Pmp Pwr @TF		and Pmp Pwr @TPL1				
52	Heat Flow	(kW)	763	99	257.2	2.489e+005			
53					Unit Ops				
54	Operation Name	Оре	eration Type	-	Feeds	Products		Ignored	Calc. Level
55 56	High Pressure Turbine @TPI	Expander		Steam	n Generator Out @Ti	PL 4 @TPL2 HP Trbn Pwr @TPL	.2	No	500.0 *
57 58	Intermdiate Pressure Turbine	Expander		8 @TI	PL2	13 @TPL2 IT Trbn Stg 1 Pwr @	nTPI 2	No	500.0 *
59 60	Intermediatte Pressure Turbi	Expander		15 @	TPL2	18 @TPL2 ITTrbn Stg 2 Pwr @		No	500.0 -
61	Low Pressure Turbine Stage	Expander		21 @	TPL2	24 @TPL2		No	500.0 °
62 63	Low Pressure Turbine Stage	Expander		25 @	TPL2	LP Trb Stg 1 Pwr @ 43 @TPL2		No	500.0 *
64						LP Trbn Stg 2 Pwr	@TPL2		
65	Low Pressure Turbine Stage	Expander		44 @		47 @TPL2		No	500.0 °
66	Hyprotech Ltd. Licensed to: INL			HYSYS	S.Plant v2.2.2 (Build	1 3000)			Page 20 of 22 * Specified by user.

Second	1	<u></u>			Case Name:	C:\D	ocuments and Settings\mgq\D	esktop\NGNP\F	Y 09 Report\750 C I
Determine: Wed May 12 10.51.54 2010	2				Unit Set				
Workbook: Rankine Steam Cycle (TPL2) (continued)	4	HYPROTECH					<u>" </u>		
Workbook: Rankine Steam Cycle (TPL2) (continued)	5	r			Date/Time:	Wed	May 12 10:51:54 2010		
	7	Workb	ook: Rankine	Stea	am Cycle	Γ)	PL2) (continu	ed)	
1	-			Uni	t Ops (contin	ued)		
1.5 Low Pressure Turbine Stage Expander	11	Operation Name	Operation Type		Feeds		Products	Ignored	Calc. Level
Low Pressure Turbine Stage Expander	-	Low Pressure Turbine Stage	Expander			_		No	500.0 *
15 Low Pressure Turbine Stage Expander	-	Low Pressure Turbine Stage	Expander	51 @1	TPL2	\dashv		No	500.0 *
17 T4 @TPL2		Low Pressure Turbine Stage	Expander	54 @1	TPL2		64 @TPL2	No	500.0 *
13 16 17 12 12 14 17 12 10 10 10 10 10 10 10	-	T4 @TPL2	Tee	4 @TF	PL2	\dashv	To Reheater @TPL2	No	500.0 °
15 15 15 15 15 15 15 15	-		_	13 @	TPL2	\dashv			
Tell	20	T6 @TPL2	Tee					No	500.0 *
24	-	T7 @TDL2	Too	18 @	TPL2		21 @TPL2	No	500.0.7
1	22	17 @1PL2	ree				22 @TPL2	No	500.0
1	-	TR ATPL 2	Тее	24 @	TPL2		25 @TPL2	No	500.0 *
10 Section	24	10 @1FL2	100			_	26 @TPL2	140	300.0
1	-	T9 @TPL2	Tee	43 @	TPL2	_		No	500.0*
The content of the	-	10 @ 11 22	100			_		140	300.0
11 TPL2 Tee	-	T10 @TPL2	Tee	47 @	TPL2	_		No	500.0 *
This properties Tee 2	-	110 @ 11 22	100			_			000.0
Tight Tigh		T11 @TPL2	Tee	53 @	TPL2	-		No	500.0 *
The content of the	-					\rightarrow			
Seedwater Heater 7 @TPL2 Heat Exchanger 11 @TPL2 10 @TPL2	31	T13 @TPL2	Tee	2 @TF	PL2	-	-	No	500.0 *
To FW Heater 7 @TPL2	33			11 @	TPL2	\neg	_		
Feedwater Heater 5 @TPL2 Fleat Exchanger 16 @TPL2 28 @TPL2 No 500.0°	34	Feedwater Heater 7 @TPL2	Heat Exchanger	To FV	V Heater 7 @TPL2	2		No	500.0
16 @TPL2	35	Facility of the OTRIO	Uset Freehouses	35 @1	TPL2		17 @TPL2	NI-	500.01
Feedwater Heater S @ IPLZ Heat Exchanger 20 @ IPLZ 38 @ IPLZ 39 @ IPLZ 36 @ IPLZ 37 @ IPLZ 36 @ IPLZ 37 @ IP	36	reedwater Heater 6 @1PL2	Heat Exchanger	16 @	ΓPL2		28 @TPL2	140	500.0
Second S	37	Fooduster Hoster 5 @TDI 2	Heat Evelopeer	27 @	ΓPL2		35 @TPL2	Ne	600.0
Feedwater Heater 3 @TPL2	38	reedwater Heater 5 @1PL2	Heat Exchanger	20 @1	ΓPL2		38 @TPL2	140	500.0
45 @TPL2	_	Fooduster Heater 2 @TBI 2	Heat Evelander	48 @7	TPL2		39 @TPL2	No	500.0 *
Feedwater Heater 2 @TPL2	40	reedwater Heater 5 @1FL2	Heat Exchanger	45 @T	TPL2		46 @TPL2	140	500.0
See	_	Foodurator Hostor 2 @TDL2	Heat Evelopeer	57 @1	TPL2		48 @TPL2	No	600.0 *
Feedwater Heater 1 @TPL2 Heat Exchanger 74 @TPL2 60 @TPL2 No 500.0°	42	reedwater Heater 2 @TFL2	Heat Exchanger	36 @	TPL2		56 @TPL2	140	300.0
Main	-	Feedwater Heater 1 @TDI 2	Heat Evolunger				57 @TPL2	No	500.0 *
Solier Feed Pump @TPL2 Pump BF Pmp Pwr @TPL2 27 @TPL2 No 500.0°	-	recurater reater regin L2	ricat Exchanger	74 @	TPL2	_	60 @TPL2	140	300.0
BF Pmp Pwr@IPL2 10	\blacksquare	Boiler Feed Pump @TPL2	Pump			_	11 @TPL2	No	500.0
Booster Pump @TPL2 Pump Bstr Pmp Pwr @TPL2 S8 @TPL2 No 500.0 °	$\boldsymbol{\vdash}$	201101 1 202 1 2111p Q 11 22			-	\rightarrow			
Bit	-	Booster Pump @TPL2	Pump	_		\dashv	27 @TPL2	No	500.0 *
Condensate Pump @TPL2 Pump Cnd Pmp Pwr @TPL2 No S00.0°	-					\rightarrow	SO OTRI O		
55 M3 @TPL2 Mixer 34 @TPL2 16 @TPL2 No 500.0° 52 M4 @TPL2 Mixer 22 @TPL2 20 @TPL2 No 500.0° 54 M4 @TPL2 Mixer 22 @TPL2 20 @TPL2 No 500.0° 55 Deaerating Heater @TPL2 Mixer 41 @TPL2 No 500.0° 57 26 @TPL2 No 500.0° 58 M11 @TPL2 Mixer 55 @TPL2 74 @TPL2 No 500.0° 69 M13 @TPL2 Mixer 52 @TPL2 36 @TPL2 No 500.0° 60 M14 @TPL2 Mixer 59 @TPL2 62 @TPL2 No 500.0° 61 M14 @TPL2 Mixer 59 @TPL2 62 @TPL2 No 500.0° 62 M7 @TPL2 Mixer 81 @TPL2 3 @TPL2 No 500.0° 64 M7 @TPL2 Mixer 81 @TPL2 3 @TPL2 No 500.0° 65 Hyprotech Ltd. HYSYS, Plant V2.2.2 (Build 3806	-	Condensate Pump @TPL2	Pump			\rightarrow	58 @TPL2	No	500.0 *
Miser Miser Mixer Mixe	5U 64		•			\dashv	16 ATDL 2		
Mary	52	M3 @TPL2	Mixer			\dashv	IV @IPL2	No	500.0 *
Mark	-					\dashv	20 @TPL2		
Second	54	M4 @TPL2	Mixer			\dashv		No	500.0 *
56 Deaerating Heater @TPL2 Mixer 41 @TPL2 No 500.0° 57 58 @TPL2 74 @TPL2 No 500.0° 58 M11 @TPL2 Mixer 55 @TPL2 74 @TPL2 No 500.0° 60 M13 @TPL2 Mixer 52 @TPL2 36 @TPL2 No 500.0° 62 M7 @TPL2 Mixer 81 @TPL2 3 @TPL2 No 500.0° 64 M7 @TPL2 Mixer 81 @TPL2 3 @TPL2 No 500.0° 65 HYSYS.Plant v2.2.2 (Build 3806) Page 21 of 22	=			_		\dashv	40 @TPL2		
ST ST ST ST ST ST ST ST	56	Deaerating Heater @TPL2	Mixer			\dashv		No	500.0 *
55 M11 @TPL2 Mixer 55 @TPL2 74 @TPL2 No 500.0° 60 M13 @TPL2 Mixer 52 @TPL2 36 @TPL2 No 500.0° 61 M13 @TPL2 Mixer 59 @TPL2 62 @TPL2 No 500.0° 62 M14 @TPL2 Mixer 59 @TPL2 62 @TPL2 No 500.0° 64 M7 @TPL2 Mixer 81 @TPL2 3 @TPL2 No 500.0° 65 Hyprotech Ltd. HYSYS,Plant v2.2.2 (Build 3806) Page 21 of 22	57								
Mixer 37 @TPL2 No 500.0°		· · · · · · · · · · · · · · · · · · ·				\neg	74 @TPL2		
M13 @TPL2 Mixer 52 @TPL2 36 @TPL2 No 500.0 ° 10	59	M11@1PL2	Mixer					No	500.0 *
MI3 @ IPL2 Mixer	60	MAC OTDLO	Mina				36 @TPL2	NI-	500.0
M14 @TPL2 Mixer 78 @TPL2 No 500.0 °	61	WII3@IPL2	iviixer					NO	500.0
78 @ IPL2	62	M14 @TDL2	Miyer	59 @T	TPL2		62 @TPL2	N-	500.0
65 M7 @TPL2 Mixer 82 @TPL2 No 500.0° 66 Hyprotech Ltd. HYSYS.Plant v2.2.2 (Build 3806) Page 21 of 22	63	WII4 @IPLZ	IVIIAEI	78 @	TPL2			140	500.0
66 Hyprotech Ltd. HYSYS.Plant v2.2.2 (Build 3806) Page 21 of 22	64	M7 @TPL2	Mixer				3 @TPL2	No	500.0 *
	65		MINOR					140	
	66	Hyprotech Ltd.		HYSYS	S.Plant v2.2.2 (Bui	ild 38	306)		Page 21 of 22

1			Case Name: C:\	Documents and Settings\mgq\D	eekton\NGNP\E	Y 00 Report\750.0
2		INL Calgary, Alberta	Unit Set: NG	3 3.	C-SKIOPHYOHY'IF	1 09 Kepokk/50 C r
4	HYPROTECH	CANADA				
5 6	PT:		Date/Time: We	ed May 12 10:51:54 2010		
7	Workb	ook: Rankine	Steam Cycle (TPL2) (continu	ed)	
9 10			Unit Ops (continue	d)		
11	Operation Name	Operation Type	Feeds	Products	Ignored	Calc. Level
12	VLV 8 @TPL2	Valve	38 @TPL2	41 @TPL2	No	500.0 °
13	VLV 10 @TPL2	Valve	46 @TPL2	49 @TPL2	No	500.0
14 15	VLV 11 @TPL2 VLV 18 @TPL2	Valve Valve	56 @TPL2 10 @TPL2	37 @TPL2 34 @TPL2	No	500.0 * 500.0 *
16	VLV 17 @TPL2	Valve	28 @TPL2	23 @TPL2	No No	500.0 °
17	VLV 13 @TPL2	Valve	60 @TPL2	59 @TPL2	No	500.0 °
18	Condenser @TPL2	Cooler	64 @TPL2	78 @TPL2	No	500.0 *
19	Condenser @11 E2	000101		Cond Q @TPL2	110	555.5
20 21	Steam Generator @TPL2	LNG	63 @TPL2 Steam Generator In @TPL2		No	500.0 *
22 23	Reheater @TPL2	LNG	79 @TPL2	82 @TPL2	No	500.0 *
23 24			To Reheater @TPL2	8 @TPL2		3500 *
24 25	ADJ-1 @TPL2 ADJ-2 @TPL2	Adjust Adjust			Yes Yes	3500
26	Efficiency Calculations @TP				No	500.0 *
27	Pressure Drops @TPL2	Spreadsheet			No	500.0 *
29 30 31 32 33 34 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 61 52 53 54 55 56 57 58 59 60 61 62 63 64						
60 61 62 63 64 65	Hyprotech Ltd.		HYSYS.Plant v2.2.2 (Build 3	806)		Page 22 of 22
~	Licensed to: INL		111010.1 Idin V2.2.2 (Dalla 3	0001		* Specified by user.

Appendix B High Temperature Electrolysis with Combined Cycle Process Flow Diagrams

The model of the HTE process with a Ranke power cycle and results in Appendix A were developed using HYSYS.Plant Version 2.2.2 (Build 3806) from Hyprotech Ltd. on a desktop computer running Microsoft Windows XP Professional Version 2002 Service Pack 3.

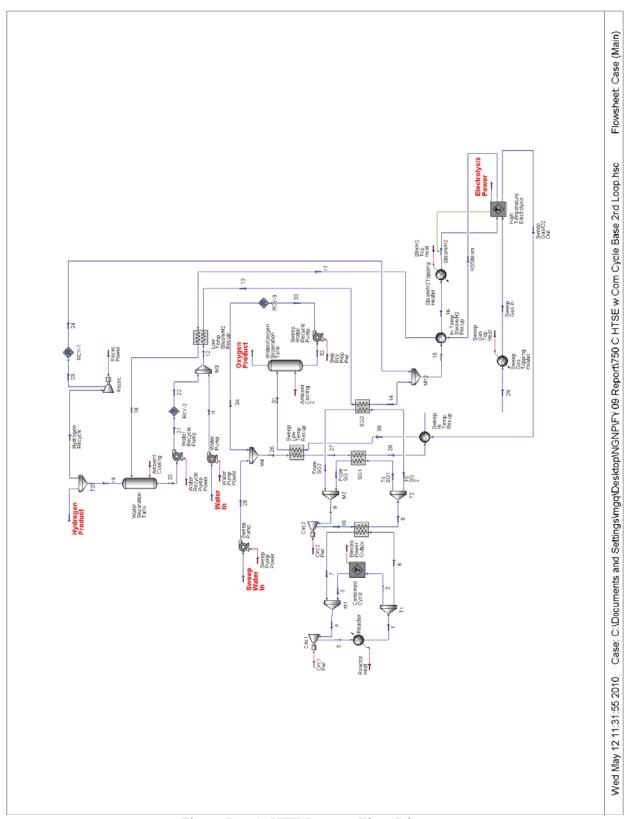


Figure B - 1 HTE Process Flow Diagram

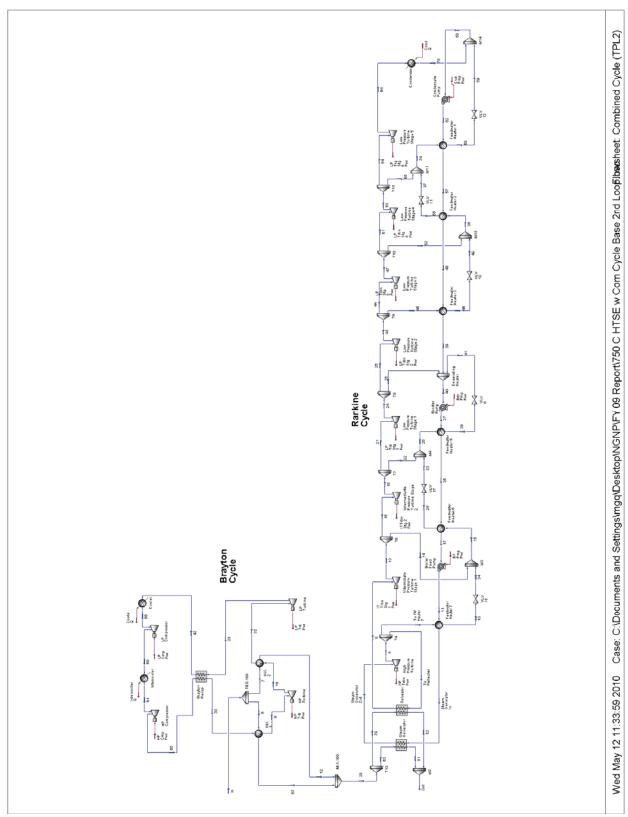


Figure B - 2 Combined Power Cycle

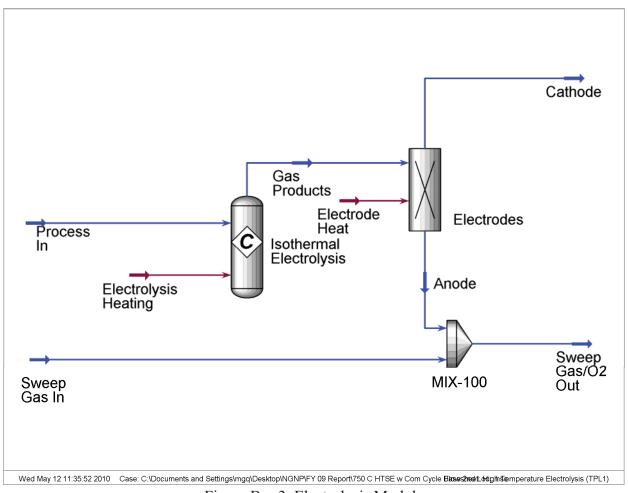


Figure B - 3 Electrolysis Module

1	~			Case Name:	C:\Documents and Set	tings\mgq\Desktop\NGN	P\EY 09 Report\750 C
2		INL Calgary, A	Alberta	Unit Set:	NGNP	ungaungqiDeakiopii4014	1 11 1 03 1(epoi(1/30 0)
4	HYPROTEC	CANADA	aborta.	Date/Time:	Wed May 12 11:37:15	2010	
5	P.			Date/Time:	Wed May 12 11:37:15	2010	
6 7 8	Wor	kbook:	Case (Main	1)			
9 10				Streams			
11	Name		1	2	3	4	5
12	Vapour Fraction		1.0000	1.0000	1.0000	1.0000	1.0000
13	Temperature	(C)	750.00 °	750.00	305.22	308.71	322.00 °
14	Pressure	(MPa)	7.0000 *	7.0000	6.7200	6.7200	7.0710
15	Molar Flow	(kgmole/s)	67.474	60.736	60.736	67.474	67.474
16	Mass Flow	(kg/s)	270.10	243.13	243.13	270.10	270.10
17	Liquid Volume Flow	(m3/h)	7837	7055	7055	7837	7837
18	Heat Flow	(kW)	1.022e+006	9.196e+005	3.581e+005	4.027e+005	4.216e+005
19	Molar Enthalpy	(kJ/kgmole)	1.514e+004	1.514e+004	5896	5969	6248
20 21	Name Vapour Fraction		1.0000	7 1.0000	1.0000	9 1.0000	1.0000
22	Vapour Fraction Temperature	(C)	750.00	340.15	725.00	304.80	315.15
23	Pressure	(C) (MPa)	7.0000	6.7200	7.0000	6.8600	7.1400
24	Molar Flow	(kgmole/s)	6.7377	6.7377	6.7412	6.7412	6.7412
25	Mass Flow	(kg/s)	26.971	26.971	26.985	26.985	26.985
26	Liquid Volume Flow	(m3/h)	782.6	782.6	783.0	783.0	783.0
27	Heat Flow	(kW)	1.020e+005	4.462e+004	9.856e+004	3.970e+004	4.117e+004
28	Molar Enthalpy	(kJ/kgmole)	1.514e+004	6622	1.462e+004	5889	6107
29	Name	()	11	12	13	14	15
30	Vapour Fraction		0.0000	0.0000	0.2711	1.0000	1.0000
31	Temperature	(C)	27.317	26.894	268.86	700.00 *	650.93
32	Pressure	(MPa)	5.4000	5.4000	5.3000	5.2000	5.2000
33	Molar Flow	(kgmole/s)	0.87296	1.3115	1.3115	1.3115	1.4574
34	Mass Flow	(kg/s)	15.727	23.627	23.627	23.627	23.923
35	Liquid Volume Flow	(m3/h)	56.73	85.23	85.23	85.23	100.4
36	Heat Flow	(kW)	-2.489e+005	-3.740e+005	-3.366e+005	-2.842e+005	-2.842e+005
37	Molar Enthalpy	(kJ/kgmole)	-2.851e+005	-2.852e+005	-2.567e+005	-2.167e+005	-1.950e+005
38	Name		16	17	18	19	20
39	Vapour Fraction		1.0000	1.0000	0.7726	1.0000	0.0000
40 41	Temperature	(C)	756.90	670.93	144.07	26.000	26.000 *
_	Pressure	(MPa)	5.1000	4.9000	4.8000	4.8000	4.8000
42 43	Molar Flow Mass Flow	(kgmole/s)	1.4574 23.923	1.4574 9.9330	1.4574 9.9330	1.0210	0.43636 7.8607
44	Liquid Volume Flow	(kg/s) (m3/h)	23.923	134.4	134.4	2.0724 106.0	28.36
45	Heat Flow	(kW)	-2.778e+005	-7.572e+004	-1.131e+005	-183.2	-1.245e+005
46	Molar Enthalpy	(kJ/kgmole)	-1.906e+005	-5.195e+004	-7.761e+004	-179.4	-2.852e+005
47	Name	(nonginole)	21	22	23	24	25
48	Vapour Fraction		0.0000	0.0000	1.0000	1.0000	0.0000
49	Temperature	(C)	26.052	26.052 *	35.491	35.491 *	27.317
50	Pressure	(MPa)	5.4000	5.4000 "	5.2000	5.2000 *	5.4000
51	Molar Flow	(kgmole/s)	0.43636	0.43857 *	0.14626	0.14585*	4.8166e-004
52	Mass Flow	(kg/s)	7.8607	7.9004	0.29685	0.29604	8.6772e-003
53	Liquid Volume Flow	(m3/h)	28.36	28.50	15.19	15.15	3.130e-002
54	Heat Flow	(kW)	-1.245e+005	-1.251e+005	13.74	13.70	-137.3
55	Molar Enthalpy	(kJ/kgmole)	-2.852e+005	-2.852e+005	93.95	93.95	-2.851e+005
56 57	Name Vancus Fraction		26	27	28	29	30
58	Vapour Fraction	(0)	0.0000	1.0000	1.0000	1.0000	1.0000
58	Temperature Pressure	(C)	27.053	346.76	700.00		755.74
60	Molar Flow	(MPa) (kgmole/s)	5.4000 0.43731	5.3000 0.43731	5.2000 0.43731	5.1000 0.43731	4.9000 0.87449
61	Mass Flow	(kgmole/s) (kg/s)	7.8790 *	7.8790	7.8790	7.8790	21.869
62	Liquid Volume Flow	(m3/h)	28.42	28.42	28.42	28.42	72.69
63	Heat Flow	(kW)	-1.247e+005	-1.013e+005	-9.477e+004	-9.326e+004	-8.324e+004
64	Molar Enthalpy	(kJ/kgmole)	-2.851e+005	-2.316e+005	-2.167e+005	-2.133e+005	-9.518e+004
65		(nonginoid)	2.3010.000	2.0100.000	2.1070.000	2.1000.000	0.0100.004
66	Hyprotech Ltd.		HYS	SYS.Plant v2.2.2 (Bui	ld 3806)		Page 1 of 23
- 1	Licensed to: INI		1111				

4							
2		INL		Case Name:	C:\Documents and Setti	ngs\mgq\Desktop\NGNI	P\FY 09 Report\750 C I
3	HYPROTEC	Coloony A	Alberta	Unit Set:	NGNP		
5		CANADA		Date/Time:	Wed May 12 11:37:15	2010	
6	\A(1	-	0 (14-:-) (4°	-1\		
8	vvori	кроок:	Case (Main	i) (continue	ea)		
9				Stroome (continu	and\		
10				Streams (continu			
11 12	Name Vapour Fraction		0.8172	0.0000	0.0000	0.0000	Ambient Cooling
13	Temperature	(C)	203.63	27.000	27.052	27.052	
14	Pressure	(MPa)	4.8000	4.8000	5.4000 *	5.4000 *	
15	Molar Flow	(kgmole/s)	0.87449	0.43682	0.43682	0.43682 *	
16	Mass Flow	(kg/s)	21.869	7.8703	7.8703	7.8703	
17	Liquid Volume Flow	(m3/h)	72.69	28.39	28.39	28.39	
18	Heat Flow	(kW)	-1.066e+005	-1.246e+005	-1.245e+005	-1.245e+005	-1.154e+004
19	Molar Enthalpy	(kJ/kgmole)	-1.220e+005	-2.851e+005	-2.851e+005	-2.851e+005	
20	Name		Ambient Cooling 2	Circ1 Pwr	Circ2 Pwr	Electric Power Out	Electrolysis Power
21	Vapour Fraction						
22	Temperature	(C)					
23	Pressure	(MPa)					
24 25	Molar Flow	(kgmole/s)					
26	Mass Flow Liquid Volume Flow	(kg/s) (m3/h)					
27	Heat Flow	(kW)	-1.819e+004	1.887e+004	1468	2.467e+005	-2.170e+005
28	Molar Enthalpy	(kJ/kgmole)	-1.01861004	1.007 6+004		2.40761003	-2.1706+003
29	Name	(Ko/Kgillolo)	From SG2	From SG 1	H2/Steam	Hydrogen Product	Hydrogen Recycle
30	Vapour Fraction		1.0000	1.0000	1.0000	1.0000	1.0000
31	Temperature	(C)	294.00	375.32	800.00	26.000	26.000
32	Pressure	(MPa)	6.8600	6.8600	5.0000	4.8000	4.8000
33	Molar Flow	(kgmole/s)	5.8456	0.89558	1.4574	0.87477	0.14626
34	Mass Flow	(kg/s)	23.400	3.5850	9.9330	1.7755	0.29685
35	Liquid Volume Flow	(m3/h)	679.0	104.0	134.4	90.85	15.19
36	Heat Flow	(kW)	3.311e+004	6586	-6.932e+004	-157.0	-26.25
37	Molar Enthalpy	(kJ/kgmole)	5664	7354	-4.757e+004	-179.4	-179.4
38	Name		Oxygen Product	Process Heat 1	Reactor Heat	Recirc Power	Steam/H2
39 40			4 0000				
41	Vapour Fraction	(0)	1.0000				1.0000
	Temperature	(C) (MPa)	27.000 *				800.00 *
	Temperature Pressure	(MPa)	27.000 ° 4.8000				800.00 ° 5.0000 °
42	Temperature Pressure Molar Flow	(MPa) (kgmole/s)	27.000 ° 4.8000 0.43767				800.00 ° 5.0000 ° 1.4574
42 43	Temperature Pressure Molar Flow Mass Flow	(MPa) (kgmole/s) (kg/s)	27.000 ° 4.8000				800.00 ° 5.0000 °
42 43 44 45	Temperature Pressure Molar Flow	(MPa) (kgmole/s)	27.000 ° 4.8000 0.43767 13.999	 		 	800.00 ° 5.0000 ° 1.4574 23.923 °
42 43 44 45 46	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow	(MPa) (kgmole/s) (kg/s) (m3/h)	27.000 ° 4.8000 0.43767 13.999 44.30	 		 	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4
42 43 44 45 46	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0	 2.957e-007	 6.000e+005 °	 39.99	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005
42 43 44 45 46 47	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0	2.957e-007 Sweep Gas In	6.000e+005 * Sweep Gas Top Heat	39.99 Sweep Gas/O2 Out	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power
42 43 44 45 46 47	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat	2.957e-007 Sweep Gas In 1.0000 800.00	6.000e+005 *	39.99 Sweep Gas/O2 Out 1.0000 800.00	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power
42 43 44 45 46 47 48 49 50	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat	2.957e-007 2.957e-007 Sweep Gas In 1.0000 800.00 5.0000	6.000e+005 * Sweep Gas Top Heat	 39.99 Sweep Gas/O2 Out 1.0000 800.00 5.0000	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power
42 43 44 45 46 47 48 49 50	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat	2.957e-007 2.957e-007 Sweep Gas In 1.0000 800.00 5.0000 0.43731	6.000e+005 * Sweep Gas Top Heat	 39.99 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.07449	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power
42 43 44 45 46 47 48 49 50 51	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat	2.957e-007 Sweep Gas In 1.0000 800.00 5.0000 0.43731 7.8790	6.000e+005 ° Sweep Gas Top Heat	Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.67449 21.869	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power
42 43 44 45 46 47 48 49 50 51 52 53	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat	2.957e-007 Sweep Gas In 1.0000 800.00 5.0000 0.43731 7.8790 28.42	6.000e+005 * Sweep Gas Top Heat	Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power
42 43 44 45 46 47	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Heat Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat	2.957e-007 Sweep Gas In 1.0000 800.00 5.0000 0.43731 7.8790 28.42 -9.288e+004	6.000e+005 ° Sweep Gas Top Heat	Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69 -8.173e+004	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power
42 43 44 45 46 47 48 49 50 51 52 53 54	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h)	27.000 * 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat 2638	2.957e-007 Sweep Gas In 1.0000 800.00 5.0000 0.43731 7.8790 28.42	6.000e+005 * Sweep Gas Top Heat 382.8	Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power 6.094e-002
42 43 44 45 46 47 48 49 50 51 52 53 54 55	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat 2638	2.957e-007 	5weep Gas Top Heat	Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69 -8.173e+004	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power 6.094e-002
42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat 2638 Sweep Water In	2.957e-007 	Sweep Gas Top Heat	Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69 -8.173e+004 -9.346e+004 To SG 2	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power 6.094e-002 Water In
42 43 44 45 46 47 48 50 51 52 53 54 55 56 57 58	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat 2638 Sweep Water In 0.0000	2.957e-007 2.957e-007 2.957e-007 300.00 800.00 5.0000 0.43731 7.8790 28.42 -9.288e+004 -2.124e+005 Swp Rcy Pmp Pwr	5.000e+005 * 6.000e+005 * Sweep Gas Top Heat 382.8 To SG1 1.0000	Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69 -8.173e+004 -9.346e+004 To SG 2 1.0000	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power 6.094e-002 Water In
42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Molar Flow Molar Flow Molar Flow Name Vapour Fraction Temperature Pressure Molar Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (kJ/kgmole)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat 2638 Sweep Water In 0.0000 26.850 ° 0.10132 ° 4.8166e-004	2.957e-007 2.957e-007 3.000 3.000 3.000 3.43731 7.8790 28.42 -9.288e+004 -2.124e+005 Swp Rcy Pmp Pwr		Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69 -8.173e+004 -9.346e+004 To SG 2 1.0000 725.00 7.0000 5.8456	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power 6.094e-002 Water In 0.0000 26.850 ° 0.10132 ° 0.87296
42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 60 61	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kWV) (kJ/kgmole) (C) (MPa) (kgmole/s) (ky/s) (kJ/kgmole) (C) (MJ/kgmole)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat 2638 Sweep Water In 0.0000 26.850 ° 0.10132 ° 4.8166e-004 8.6772e-003	2.957e-007 Sweep Gas In 1.0000 800.00 5.0000 0.43731 7.8790 28.42 -9.288e+004 -2.124e+005 Swp Rcy Pmp Pwr		Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69 -8.173e+004 -9.346e+004 To SG 2 1.0000 725.000 7,0000 5,8456 23,400 °	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power 6.094e-002 Water In 0.0000 26.850 ° 0.10132 ° 0.87296 15.727
42 43 44 45 46 47 48 50 51 52 53 54 56 57 58 58 60 61 62	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Molar Flow Mass Flow Liquid Volume Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kWV) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (kJ/kgmole)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat 2638 Sweep Water In 0.0000 26.850 ° 0.10132 ° 4.8166e-004 8.6772e-003 3.130e-002	2.957e-007 Sweep Gas In 1.0000 800.00 5.0000 0.43731 7.8790 28.42 -9.288e+004 -2.124e+005 Swp Rcy Pmp Pwr		Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69 -8.173e+004 -9.346e+004 To SG 2 1.0000 725.00 7.0000 5.8456 23.400 679.0	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power 6.094e-002 Water In 0.0000 26.850 ° 0.10132 ° 0.87296 15.727 56.73
42 43 44 45 46 47 48 49 50 51 52 53 54 56 56 57 58 60 61 61 62 63	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Molar Flow Liquid Volume Flow Liquid Volume Flow Liquid Volume Flow Heat Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kWV) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kWV) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat 2638 Sweep Water In 0.0000 26.850 ° 0.10132 ° 4.8166e-004 8.6772e-003 3.130e-002 -137.4	2.957e-007 Sweep Gas In 1.0000 800.00 5.0000 0.43731 7.8790 28.42 -9.288e+004 -2.124e+005 Swp Rcy Pmp Pwr		39.99 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69 -8.173e+004 -9.346e+004 To SG 2 1.0000 725.00 7.0000 5.8456 23.400 679.0	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power 6.094e-002 Water In 0.0000 26.850 ° 0.10132 ° 0.87296 15.727 56.73 -2.490e+005
42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 60 61 62 63 64	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Molar Flow Mass Flow Liquid Volume Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kWV) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (kJ/kgmole)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat 2638 Sweep Water In 0.0000 26.850 ° 0.10132 ° 4.8166e-004 8.6772e-003 3.130e-002	2.957e-007 Sweep Gas In 1.0000 800.00 5.0000 0.43731 7.8790 28.42 -9.288e+004 -2.124e+005 Swp Rcy Pmp Pwr		Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69 -8.173e+004 -9.346e+004 To SG 2 1.0000 725.00 7.0000 5.8456 23.400 679.0	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power 6.094e-002 Water In 0.0000 26.850 ° 0.10132 ° 0.87296 15.727 56.73
42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 60 61 61	Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Enthalpy Name Vapour Fraction Temperature Pressure Molar Flow Molar Flow Molar Flow Liquid Volume Flow Liquid Volume Flow Liquid Volume Flow Heat Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kWV) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kWV) (kJ/kgmole) (C) (MPa) (kgmole/s) (kg/s)	27.000 ° 4.8000 0.43767 13.999 44.30 -281.0 -642.0 Stm/H2 Top Heat 2638 Sweep Water In 0.0000 26.850 ° 0.10132 ° 4.8166e-004 8.6772e-003 3.130e-002 -137.4 -2.853e+005	2.957e-007 Sweep Gas In 1.0000 800.00 5.0000 0.43731 7.8790 28.42 -9.288e+004 -2.124e+005 Swp Rcy Pmp Pwr		39.99 Sweep Gas/O2 Out 1.0000 800.00 5.0000 0.87449 21.869 72.69 -8.173e+004 -9.346e+004 To SG 2 1.0000 725.00 7.0000 5.8456 23.400 679.0	800.00 ° 5.0000 ° 1.4574 23.923 ° 100.4 -2.752e+005 -1.888e+005 Sweep Pump Power 6.094e-002 Water In 0.0000 26.850 ° 0.10132 ° 0.87296 15.727 56.73 -2.490e+005

1										
2	INL	Case Name: C:\Documents and Settings\mgq\Desktop\NGNP\FY 09 Report\750 C								
3	Calgary, A	Unit Set:	Unit Set: NGNP							
5	CHILDH	Date/Time:	Date/Time: Wed May 12 11:37:15 2010							
6 7 8	Workbook:	Case (Main	ı) (continue	continued)						
9 10	Streams (continued)									
11 Name Water Pump Power Water Recycle Pump										
12	Vapour Fraction									
13	Temperature (C)									
14 15	Pressure (MPa) Molar Flow (kgmole/s)									
16	Molar Flow (kgmole/s) Mass Flow (kg/s)									
17	Liquid Volume Flow (m3/h)									
18	Heat Flow (kW)	110.4	6.239							
19	Molar Enthalpy (kJ/kgmole)									
20 21			Composition							
22	Name	1	2	3	4	5				
23	Comp Mole Frac (Hydrogen)	0.00000 *	0.00000 *	0.00000	0.00000	0.00000				
24	Comp Mole Frac (H2O)	0.00000 *	0.00000 *	0.00000	0.00000	0.00000				
25	Comp Mole Frac (Oxygen)	0.00000 '	0.00000 *	0.00000	0.00000	0.00000				
26	Comp Mole Frac (Nitrogen)	0.00000 *	0.00000*	0.00000	0.00000	0.00000				
27 28	Comp Mole Frac (CO2)	0.00000 *	0.00000 *	0.00000	0.00000	0.00000				
29	Comp Mole Frac (Argon) Comp Mole Frac (Helium)	1.00000 *	0.00000 ° 1.00000 °	1.00000	0.00000 1.00000	1.00000				
30	Name	6	7	8	9	10				
31	Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000				
32	Comp Mole Frac (H2O)	0.00000	0.00000	0.00000	0.00000	0.00000				
33	Comp Mole Frac (Oxygen)	0.00000	0.00000	0.00000	0.00000	0.00000				
34	Comp Mole Frac (Nitrogen)	0.00000	0.00000	0.00000	0.00000	0.00000				
35	Comp Mole Frac (CO2)	0.00000	0.00000	0.00000	0.00000	0.00000				
36	Comp Mole Frac (Argon)	0.00000	0.00000	0.00000	0.00000	0.00000				
37	Comp Mole Frac (Helium)	1.00000	1.00000	1.00000	1.00000	1.00000				
38	Name	11	12	13	14	15				
39	Comp Mole Frac (Hydrogen)	0.00000	0.00002	0.00002	0.00002	0.10001				
40 41	Comp Mole Frac (H2O) Comp Mole Frac (Oxygen)	1.00000	0.99998 0.00000	0.99998	0.99998	0.89999				
42	Comp Mole Frac (Oxygen)	0.00000	0.00000	0.00000	0.00000	0.00000				
43	Comp Mole Frac (CO2)	0.00000	0.00000	0.00000	0.00000	0.00000				
44	Comp Mole Frac (Argon)	0.00000	0.00000	0.00000	0.00000	0.00000				
45	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000				
46	Name	16	17	18	19	20				
47	Comp Mole Frac (Hydrogen)	0.10001	0.70000	0.70000	0.99914	0.00005				
48	Comp Mole Frac (H2O)	0.89999	0.30000	0.30000	0.00086	0.99995				
49	Comp Mole Frac (Oxygen)	0.00000	0.00000	0.00000	0.00000	0.00000				
50 51	Comp Mole Frac (Nitrogen)	0.00000	0.00000	0.00000	0.00000	0.00000				
52	Comp Mole Frac (CO2) Comp Mole Frac (Argon)	0.00000	0.00000	0.00000	0.00000	0.00000				
53	Comp Mole Frac (Argon) Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000				
54	Name	21	22	23	24	25				
55	Comp Mole Frac (Hydrogen)	0.00005	0.00005 *	0.99914	0.99914 *	0.00000				
56	Comp Mole Frac (H2O)	0.99995	0.99995 *	0.00086	0.00086 *	1.00000				
57	Comp Mole Frac (Oxygen)	0.00000	0.00000 *	0.00000	0.00000 *	0.00000				
58	Comp Mole Frac (Nitrogen)	0.00000	0.00000 *	0.00000	0.00000 *	0.00000				
59	Comp Mole Frac (CO2)	0.00000	0.00000 *	0.00000	0.00000 *	0.00000				
60	Comp Mole Frac (Argon)	0.00000	0.00000*	0.00000	0.00000 *	0.00000				
61 62	Comp Mole Frac (Helium)	0.00000	0.00000 *	0.00000	0.00000 *	0.00000				
63 64 65										
66	Hyprotech Ltd.	HY:	SYS.Plant v2.2.2 (Build	3806)		Page 3 of 23 * Specified by user.				

No. Comp Note Frac (Hydrogen)	1									
	2	INL	Case Name:							
	3		Unit Set:	NGNP						
Workbook: Case (Main) (continued)		CANADA		Date/Time:	e/Time: Wed May 12 11:37:15 2010					
	_	Martha al-	0 (14-:-) (1 ·	-11					
10 Name	_	workbook:	Case (Main) (continue	ea)					
Name	9	Composition (continued)								
12 Comp Mole Frac (Hydrogen)	_	Name				29	30			
Comp Mole Frac (Phytogen)							0.00000			
			0.99986	0.99986		0.99986	0.50000			
Comp Mole Frac (CO2)	14	Comp Mole Frac (Oxygen)	0.00014	0.00014	0.00014	0.00014	0.50000			
Corpe Mole Frac (Hydrogen)		Comp Mole Frac (Nitrogen)	0.00000	0.00000	0.00000	0.00000	0.00000			
Comp Mole Frac (Helium)	_						0.00000			
10 Name	_						0.00000			
Comp Mole Frac (Hydrogen)	\blacksquare						0.00000			
Comp Mole Frac (HZO)										
22							0.00000			
22	21						0.00000			
Comp Mole Frac (Helium)							0.00000			
Comp Mole Frac (Helium)	24						0.00000			
Comp Mole Frac (Helium)							0.00000			
Name							1.00000			
Comp Mole Frac (Hydrogen)	_									
Comp Mole Frac (H2O)	_						0.00000			
Comp Mole Frac (Norgen)	ᆸ						0.00110			
Comp Mole Frac (CO2)							0.99890			
Comp Mole Frac (Argon)			0.00000	0.00000	0.00000	0.00000	0.00000			
Comp Mole Frac (Helium)	32	Comp Mole Frac (CO2)	0.00000	0.00000	0.00000	0.00000	0.00000			
Name		Comp Mole Frac (Argon)	0.00000	0.00000	0.00000	0.00000	0.00000			
Comp Mole Frac (Hydrogen)	34	Comp Mole Frac (Helium)	1.00000	0.00000	0.00000	0.00000	0.00000			
Comp Mole Frac (H2O)		Name	Steam/H2	Sweep Gas In	Sweep Gas/O2 Out	Sweep Water In	To SG1			
Comp Mole Frac (Oxygen)			0.10001				0.00000 *			
Comp Mole Frac (Nitrogen)							0.00000 *			
Comp Mole Frac (Argon)	38						0.00000 *			
Comp Mole Frac (Helium)							0.00000 *			
Comp Mole Frac (Helium)	40						0.00000 *			
Assume							0.00000 *			
Comp Mole Frac (Hydrogen)					0.00000	0.00000	1.00000 *			
Comp Mole Frac (H2O)	_									
Comp Mole Frac (Oxygen)										
Comp Mole Frac (Nitrogen)	_									
Comp Mole Frac (CO2)										
Comp Mole Frac (Argon)		- · · · · · · · · · · · · · · · · · · ·								
Comp Mole Frac (Helium) 1.00000										
Coolers Cool	50									
Same		. ,		Coolere						
54 Duty (kW) 55 Feed Temperature (C) 56 Product Temperature (C) 57 ** Heat Exchangers 59 Name Sweep Hi Temp Rect Hi Temp Steam/Hz R 60 Duty (kW) 1506 6394 11 UA (W/C) 4.324e+004 2.120e+005 62 LMTD (C) 34.82 30.15 63 Minimum Approach (C) 20.00 20.00 64 65 66 Hyprotech Ltd. HYSYS.Plant v2.2.2 (Build 3806) Page 4 of				Coolers						
Feed Temperature C	53									
See Product Temperature C) Heat Exchangers Heat Exchange										
Sweep Hi Temp Rect Hi Temp Steam/H2 R Sweep Hi Temp Steam/H2 R Sweep Hi Temp Rect Hi Temp Steam/H2 R S	55									
Sweep Hi Temp Rect Hi Temp Steam/H2 R		Product Temperature (C)								
59 Name Sweep Hi Temp Rec Hi Temp Steam/H2 R Sweep Hi Temp Rec Swe	5/ 58			Heat Exchange	rs					
80 Duty (kW) 1506 6394 <	59	Name	Sweep Hi Temp Recu	Hi Temp Steam/H2 R						
61 UA (W/C) 4.324e+004 2.120e+005	60	Duty (kW)	1506	6394						
63 Minimum Approach (C) 20.00 20.00	61	UA (W/C)	4.324e+004	2.120e+005						
64 65 Hyprotech Ltd.		1.7	34.82							
65 Hyprotech Ltd. HYSYS.Plant v2.2.2 (Build 3806) Page 4 of		Minimum Approach (C)	20.00	20.00						
66 Hyprotech Ltd. HYSYS.Plant ∨2.2.2 (Build 3806) Page 4 of	64									
	${}^{-}$	II		WO DI	10000		D 1 100			
Licensed to: INL *Specified by use	66		HYS	SYS.Plant v2.2.2 (Buil	a 3806)		Page 4 of 23			

1					Ones Nomes	0.10			- V 00 D		
2	1112				Case Name: C:\Documents and Settings\mgq\Desktop\NGNP\FY 09 Report\750 C						
3	Calgary, Alberta CANADA				Unit Set: NGNP						
5	Shirbh				Date/Time: Wed May 12 11:37:15 2010						
6	Workbook: Case (Main) (continued)										
8	Workbook. Case (Main) (Continued)										
9 10	Heaters										
11	Name		Steam/H2Topping	He Sw	veep Gas Topping	Reactor					
12	Duty	(kW)	263		382.8	6.000e+005 *					
13	Feed Temperature	(C)	756		780.0	322.0 *					
14 15	Product Temperature	(C)	800	.0 *	800.0	750.0 *					
16					LNGs						
17	Name		Low Temp Steam			SG2			IHX		
18	UA (Calculated)	(W/C)	4.288e+00		2.439e+005	5.213e+005	2.	469e+005	2.296e+006		
19	LMTD	(C)	87.2		26.68 *	100.4 *		94.81 *	25.00 *		
20	Exchanger Cold Duty	(kW)	3.740e+00		6508	5.236e+004	2.	341e+004	5.740e+004		
21 22	Minimum Approach	(C)	25.0		25.00	25.00		25.00	24.99		
23				(Compressors						
24	Name		Recirc	Cir	re1	Circ2					
25	Feed Pressure	(MPa)	4.80	00	6.720	6.860					
26	Product Pressure	(MPa)	5.20	00	7.071	7.140					
27	Molar Flow (F	kgmole/s)	0.146	33	67.47	6.741					
28	Energy	(kW)	39.9	-	1.887e+004	1468					
29	Adiabatic Efficiency			75 *	90 *	90 •					
30	Polytropic Efficiency		7	75	91	90					
31 32					Expanders						
33	Name										
34	Feed Pressure	(MPa)									
35	Product Pressure	(MPa)									
36		kgmole/s)									
37	Energy	(kW)									
38	Adiabatic Efficiency										
39 40	Polytropic Efficiency										
41					Pumps						
42	Name		Water Pump		ater Recycle Pump		Sweep V	Vater Recyc			
43	Delta P	(MPa)	5.299		0.6000	5.299	0.6000				
44	Energy	(kW)	110		6.239	6.094e-002		6.251			
45 46	Feed Pressure Product Pressure	(MPa) (MPa)	0.101 5.40	_	4.800 5.400	0.1013 ° 5.400		4.800 5.400 *			
47		kgmole/s)	0.873		0.4364	4.817e-004		0.4368			
48	Adiabatic Efficiency	(%)	75.0	-	75.00 °	75.00 *		75.00			
49		(,-/			Unit Ops	. 5.30					
50											
51	Operation Name	Ope	eration Type	6 1	Feeds	Products		Ignored	Calc. Level		
52	Link Townson Co.	C4	Cub Flourities	Steam/		H2/Steam		M-	0.000		
53 54	High Temperature Electrolys	Standard	Sub-Flowsheet		Gas In	Sweep Gas/02 Ou		No	2500 *		
55				2	s Heat 1	Electrolysis Power					
56	Combined Cycle	Standard	Sub-Flowsheet			Electric Power Ou	t	No	2500 *		
57			neet					No	500.0 *		
58	Efficiency	Spreadsh	neet					No	500.0 *		
59 60	Steam/H2Topping Heater	Heater		16 Stm/H2	Top Heat	Steam/H2		No	500.0 *		
61				29	H2 Top Heat Sweep Gas In						
62	Sweep Gas Topping Heater Heater				ep Gas Top Heat			No	500.0 *		
63	Reactor Heater			5	1			No	500.0 *		
64				Reacto	or Heat	Uhudana - Barata da					
65 ee	T20	Tee		19	Planty 2.2.2 (P. III	Hydrogen Product		No	500.0 °		
66	Hyprotech Ltd.			HYSYS.	Plant v2.2.2 (Build	1 38U6)			Page 5 of 23		

INL Calgary, Alberta CANADA Unit Set: NGNP Date/Time: Wed May 12 11:37:15 2010 Workbook: Case (Main) (continued) Unit Ops (continued)	eport\750 C										
Date/Time: Wed May 12 11:37:15 2010	Case Name: C:\Documents and Settings\mgq\Desktop\NGNP\FY 09 Report\750 C										
Workbook: Case (Main) (continued)											
Workbook: Case (Main) (continued)	Date/Time: Wed May 12 11:37:15 2010										
	Workbook: Case (Main) (continued)										
Comparation Name	Unit Ops (continued)										
Ti	ılc. Level										
1	500.0*										
12	500.0 *										
Sweep H\$ Temp Recup	500.0 *										
Sweep Saar/02 Out 16 16 No No	500.0 *										
Heat Exchanger											
Miles	500.0 *										
M3	500.0 *										
M4	500.0 *										
M4											
Mile	500.0 *										
M2	500.0 *										
Recirc Compressor Hydrogen Recycle 23	500.0 *										
Signature Compressor Circ1 Pwr Signature Circ1 Pwr Signature Circ2 Pwr Signature Signature Circ2 Pwr Signature Sig	500.0 °										
S	500.01										
Circ2 Pwr	500.0										
Solid Signature Signatur	500.0 *										
SG1	500.0 *										
A1	500.0 *										
To SG 2 From SG2 No											
HIX	500.0 *										
HIX	500.0 *										
Water Pump Pump Water In 11											
Water Pump Pump Water Pump Power No	500.0*										
A0	500.0*										
Water Recycle Pump Power Sweep Pump Pump Sweep Water In 25 No	500.0 *										
Sweep Pump Sweep Pump Power Sweep Pump Power											
18	500.0 *										
31 32 No No	500.0 *										
31 32 No No											
80 Ambient Cooling 2 81 RCY-1 Recycle 23 24 No 82 RCY-2 Recycle 21 22 No 83 RCY-3 Recycle 33 34 No 84 SET-1 Set No	500.0 *										
80 Ambient Cooling 2 81 RCY-1 Recycle 23 24 No 82 RCY-2 Recycle 21 22 No 83 RCY-3 Recycle 33 34 No 84 SET-1 Set No											
62 RCY-2 Recycle 21 22 No 63 RCY-3 Recycle 33 34 No 64 SET-1 Set No	500.0 °										
63 RCY-3 Recycle 33 34 No 64 SET-1 Set No	3500 *										
64 SET-1 Set No	3500 *										
	3500 ° 500.0 °										
1.00	500.0										
	ge 6 of 23										

2	Dr.		NL	Case Name:	Case Name: C:\Documents and Settings\mgq\Desktop\NGNP\FY 09 Report\750 C							
3	HY	FROTECH	Calgary, Alberta CANADA	Unit Set:	Unit Set: NGNP							
4 5			ZANADA	Date/Time:	Date/Time: Wed May 12 11:37:15 2010							
6	Weatherst Occasion (Main) (acadimus I)											
8	Workbook: Case (Main) (continued)											
9 10		Unit Ops (continued)										
11												
12 13	ADJ-1		Adjust			No	3500					
14 15		Spread	sheet: Efficie	ency			Units Set: NGNP					
16 17				CONNECTIO	NS							
18 19				Imported Varia	bles							
20	Cell	(Object		Variable Description		Value					
21	B1	Energy Stream		Heat Flow			6.000e+005 kW					
22	B2	Energy Stream		Power			2.467e+005 kW					
23	B3	Energy Stream:		Power			1.887e+004 kW					
24	B4	Energy Stream:	·	Power			-2.170e+005 kW					
25	B5	Energy Stream:		Power			39.99 kW					
26 27	B6 B7		Water Pump Power	Power			110.4 kW					
28	B8	Energy Stream		Power			6.094e-002 kW					
29	B9	Energy Stream		Power			6.239 kW 6.251 kW					
30	D1	Energy Stream: Energy Stream:		Power Heat Flow			-1.154e+004 kW					
31	D2		: Ambient Cooling 2	Heat Flow			-1.819e+004 kW					
32	D7	**	Hydrogen Product	Mass Higher Heating Va	IIA		1.393e+005 kJ/kg					
33	D8		Hydrogen Product	Mass Flow	ue		1.7755 kg/s					
34	D9			Heat Flow			382.8 kW					
34 D9 Energy Stream: Sweep Gas Top Heat Heat Flow 35 D10 Energy Stream: Stm/H2 Top Heat Heat Flow							2638 kW					
36 F2 Energy Stream: Circ2 Pwr Power							1468 kW					
37 F3 Tee: T1 Flow Ratio (Flow Ratio_2)							0.9001					
38 39			Expo	rted Variables' For								
40	Cell	(Object		Variable Description		Value					
41 42				PARAMETER	ls .							
43 44				Exportable Vari	ables							
45	Cell	Visit	ole Name	Variable De	scription	Variable Type	Value					
46	B10	B10: Total Electrical	Power	Total Electrical Power		Power	-0.2106 kW					
47	D3	D3:				Energy	2.972e+004 kW					
48	D4	D4:				Energy	133.8 kW					
49	D5	D5:					0.9600					
50	D6	D6:				Power	-2.261e+005 kW					
51 52	F1 F4	F1: Hydrogen Produ	ction Efficiency	Hydrogen Production Eff		Percent 	41.02					
53	Г4	F4:		Haca Mantala			0.4253					
52 53 54 55 56				User Variabl								
56				FORMULAS	3							
57	Cell	_no no	7 DO DO DA	Formula			Result					
58	B10	=B2-B3+D6-B5-B6-I	B/-B8-B9-D4-F2				-0.2106 kW					
59 60	D3	=-D1-D2	2 0 000000174507				2.972e+004 kW					
60	D4 D6	=0.00450015022*D	o- 0.0000921/453/				133.8 kW					
62	F1	=B4/D5 =(D7*D8)/(B1+D9+D	110*100				-2.261e+005 kW 41.02					
63	F4	=(B2-F3*B3)/(B1*F3					0.4253					
63 64 65		-(D2-10 D3)/(D1 T3	"				0.7200					
65												
66	Hyprote	ch Ltd.		HYSYS.Plant v2.2.2 (B	ild 3806)		Page 7 of 23					
_	Licensed to:						T Specified by year					

2	3		INL	Case N	Case Name: C:\Documents and Settings\mgq\Desktop\NGNP\FY 09 Report\750 0					
3	Calgary, Alberta			Unit Se	t: NGNP	NGNP				
5	CANADA			Date/Ti	me: Wed Ma	: Wed May 12 11:37:15 2010				
6										
7		Spreadsheet: Efficiency (continued) Units Set: NGNP								
9	Spreadsheet									
10 11		Α	В	C	D		E	F		
12	1	Reactor Heat *	6.000e+005 kW *	Ambient Coolin		+004 kW	n Production Efficiency *	41.02		
13	2	Electric Power Out *	2.467e+005 kW	Ambient Cooling			Circ 2 Pwr *	1468 kW		
14	3	Circ Pwr *	1.887e+004 kW	Total Ambient Coolin	_	+004 kW	flo frc into pwr cycl *	0.9001		
15 16	4 5	DC Electrolysis Power * Recirc Pwr *	-2.170e+005 kW 39.99 kW	Power to Ambient Co AC to DC conversion				0.4253		
17	6	Water Pump Power *	110.4 kW	AC Electrolysis Power						
18	7	Sweep Pump Pwr *	6.094e-002 kW	HHV H2 Produ						
19	8	Recycle Pmp Pwr	6.239 kW	Mass Flow Hydroge		755 kg/s				
20		weep Rcycl Pump Pwr	6.251 kW	veep Gas Topping He		82.8 kW				
21	10	Total Electrical Power *	-0.2106 kW	Process Topping Hea	at *	2638 kW				
22 23		Spread	dsheet: Elec	trolveje In	nut and	Out	out :	Jnits Set: Electrolysis		
24		Spieat	asileet. Elet	Li Oiysis iii	put anu	Out	Jui	office Sec. Electrolysis		
25 26				CONNE	CTIONS					
27				Imported	Variables					
28 29			Obi - I	Imported				V-1		
30	Ce		Object r: Isothermal Electrolysi	s 6 Act % Conversion	Variable D			Value 66.67		
31		- Communication Module		ported Variable				00.01		
32	Ce	II	Object	ported variable	Variable D			Value		
34		"	Object	PARAM	IETERS	escription		Value		
35 36										
37				Exportable	e Variables					
38	Ce		ible Name	Varia	able Description		Variable Type	Value		
39	B1 B2			Number of Calle				<empty> 1.073e+006</empty>		
40 41	B3			Number of Cells Cell Area			Small Area	225.0 cm2		
42	B4		y (Amperes/cm^2)	Current Density	Amperes/cm^2)			0.6989		
43	B			ASR @ 1100 K (0.2776		
44	B7	7 B7:						<empty></empty>		
45 46				User Va	ariables					
47 48				FORM	IULAS					
49	Ce	II		Formula				Result		
50 51				Sprea	dsheet					
52										
53	1		<empty> *</empty>							
54	2	Number of Cells *	1.073e+006 *							
55 56	3	Cell Area	225.0 cm2 *							
56 57		ensity (Amperes/cm^2) * ② 1100 K (ohms*cm^2) *	0.6989 ° 0.2776 °							
58	6 66.67									
59	7 <empty> *</empty>									
60	8									
61	9									
62 63	10									
64										
65										
66	Нур	rotech Ltd.		HYSYS.Plant v2	.2.2 (Build 3806)			Page 8 of 23		
	11	ed to: INL						* Specified by user.		

1					Ozza Namo		Danimanta and Catti			NEV 00 D+1750 O
2		INL	Mr. and a			_		ngsvmgqvD	esktopiivGivr	VFY 09 Report\750 C I
3	HYPROTECH	Calgary, A CANADA	Alberta			G۱				
5	pe-			_	Date/Time: W	/ec	d May 12 11:37:15 2	2010		
7	Workb	ook:	High Ten	np	erature Elec	ct	trolysis (T	PL1))	
9 10					Streams					
11	Name		Process In @TP	L1	Sweep Gas In @TPL	C	athode @TPL1	Sweep G	as/02 Out (Gas Products @TPL
12	Vapour Fraction		1.00	_	1.0000		1.0000		1.0000	1.0000
13	Temperature	(C)	800.0		800.00		* 00.00		800.00	800.00
14	Pressure	(MPa)	5.00		5.0000		5.0000		5.0000	5.0000
15 16		(gmole/s)	1.45		0.43731		1.4574		0.87449	1.8946
17	Mass Flow Liquid Volume Flow	(kg/s) (m3/h)	23.9		7.8790 28.42		9.9330 134.4		21.869 72.69	23.923 178.7
18	Heat Flow	(kW)	-2.752e+0		-9.288e+004		-6.932e+004	_0	173e+004	-5.825e+004
19		J/kgmole)	-1.888e+0		-2.124e+005		-4.757e+004		346e+004	-3.075e+004
20	Name		Liquid Products (Anode @TPL1	M	lolar Flow of Oxyger		sis Heating (Electrode Heat @TPI
21	Vapour Fraction		0.00		1.0000					
22	Temperature	(C)	800.0		804.96					
23	Pressure	(MPa)	5.00		5.0000					
24	Molar Flow (F	(gmole/s)	0.000	00	0.43719		0.43719			
25	Mass Flow	(kg/s)	0.000	00	13.990		13.990			
26	Liquid Volume Flow	(m3/h)	0.00	00	44.27		44.27			
27	Heat Flow	(kW)	0.00	_	1.115e+004			2.	170e+005	72.15
28		l/kgmole)	-2.975e+0	_	2.549e+004	_				
29	Name		Process Heat @		Electrolysis Power @					
30	Vapour Fraction	(0)								
31 32	Temperature Pressure	(C)								
33		(MPa) (gmole/s)		_		_				
34	Mass Flow	(kg/s)								
35	Liquid Volume Flow	(m3/h)								
36	Heat Flow	(kW)	2.957e-0	07	-2.170e+005					
37		J/kgmole)								
38	,,				Heit One					
39					Unit Ops					
40	Operation Name	Оре	eration Type		Feeds	\perp	Products		Ignored	Calc. Level
41				Pr	ocess in @TPL1	4	Liquid Products @7	TPL1		
42	Isothermal Electrolysis @TP	Conversi	on Reactor	Ele	ectrolysis Heating @TPL	.1	Gas Products @TF		No	500.0 *
43						+	Electrolysis Heatin			
44	MIV 400 CTD: 4				quid Products @TPL1	+	Sweep Gas/O2 Ou	t @TPL1		
45 46	MIX-100 @TPL1	Mixer		_	ode @TPL1	+			No	500.0 *
47				_	veep Gas In @TPL1 as Products @TPL1	+	Cathode @TPL1			+
48	Electrodes @TPL1	Compone	ent Splitter		ectrode Heat @TPL1	+	Anode @TPL1		No	500.0 *
49	Gas Product Temperature @	Set			Jon Jao i lour Will El	+	, slower well El		No	500.0 *
50	Outlet Temperature @TPL1	Set				1			No	500.0 *
51	Outlet Pressure @TPL1	Set							No	500.0 *
52	Inlet Temperature @TPL1	Set				I			No	500.0 *
53	High Temperature Electrolys	Spreadsh				1			No	500.0 °
54	Temp Average ASR @TPL1	Spreadsh	neet			4			No	500.0 *
55	ADJ-1 @TPL1	Adjust				+			No	3500 *
56 57	ADJ-2 @TPL1	Adjust				_			No	3500 *
58 59	Sprea	dshe	et: High	Ге	mperature E	ΞΙ	lectrolysis	s @T	PL1 Unit	s Set: Electrolysis
60 61					CONNECTIONS	;				
62 63					Imported Variable	es	i .			
64	Cell	Object			Var	rial	ble Description			Value
65	D2 Material Strea	m: Proces	ss In @TPL1		nperature					1073.1 K
66	Hyprotech Ltd.			HY	SYS.Plant v2.2.2 (Build	38	306)			Page 9 of 23

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1		Case Name: C:\Documents and S	ettings\mgq\Desktop\N	SNP\FY 09 Report\750 C
3	INL Calgary, Alberta	Unit Set: NGNP		
4	CANADA	Date/Time: Wed May 12 11:37:	15 2010	
6		Date/fille. Wed Way 12 11.57.	13 2010	
7	Spreadsheet: High	Temperature Electrolys	sis @TPL1	Units Set: Electrolysis
9		CONNECTIONS		
11		Imported Variables		
13 Ce		Variable Description		Value
14 D		Temperature		1073.2 K
15 A	9	Pressure		5.0000e+006 N/m2
16 E:		Comp Mole Frac (H2O) Comp Mole Frac (Hydrogen)		0.89999
18 G		Comp Mole Frac (Oxygen)		0.00014
19 E	, , ,	Comp Mole Frac (H2O)		0.30000
20 F		Comp Mole Frac (Hydrogen)		0.70000
21 G	-	Comp Mole Frac (Oxygen)		0.50000
22 B1		B2: Number of Cells		1.073e+006
23 B1	2 SpreadSheetCell: Electrolysis Input and O	B3: Cell Area		225.0 cm2
24 B1	,	B4: Current Density (Amperes/cm^2)		0.6989
25 B1	, , , , ,	B2: Temp Aver ASR		0.4000
26 D1	3, , ,	Heat Flow		2.170e+005 kW
27 D1	2 Energy Stream: Electrode Heat @TPL1	Heat Flow		72.15 kW
28 29	Expo	rted Variables' Formula Results		
30 Ce	ell Object	Variable Description		Value
31 B1	7,0	Molar Flow		437.19 gmole/s
32 B1	, ,	Power		-2.170e+005 kW
33 B2	20 Process Heat @TPL1	Heat Flow		2.957e-007 kW
34 35		PARAMETERS		
36 37		Exportable Variables		
38 Ce	ell Visible Name	Variable Description	Variable Type	Value
39 A		A1 for Gibbs Formation Energy	Gibbs. Coeff. CA	2.382e+005 J/gmole
40 A		A2 for Gibbs Formation Energy	Gibbs. Coeff. CB	39.95 J/gmole-K
41 A		A3 for Gibbs Formation Energy	Gibbs. Coeff. CC	3.319e-003 kJ/gmol-K
42 A	33 (3	A4 for Gibbs Formation Energy (kJ/gmol-K^3)		-3.532e-008
43 A	- 05	A5 for Gibbs Formation Energy	Gibbs. Coeff. CB	-12.85 J/gmole-K
44 A	3 (3 /	Fa Faraday Number (J/Volt-gmole)	 Entropy	9.649e+004
45 A		R Universal Gas Constant Standard Pressure	Entropy Pressure	8.314 J/gmole-K 1.0132e+005 N/m2
47 B1		WIND THE PROPERTY OF THE PROPE		157.2
48 B1		Molar Flow	Flow	437.19 gmole/s
49 B1			Vapour Fraction	1.0067
50 B1	8 B18:		Vapour Fraction	1.2862
51 B1		Power	Power	-2.170e+005 kW
52 B2		Heat Flow	Energy	2.957e-007 kW
53 D			Temperature	-5.9483e-004 K
54 D			Temperature	1073.2 K
55 Di				3.501e-007
57 E			Vapour Fraction	5.887e-004 -0.6000
58 E			Vapour Fraction	0.3336
59 F4			Vapour Fraction	0.6000
60 F			Vapour Fraction	-0.6194
61 G			Vapour Fraction	0.4999
62 G			Vapour Fraction	-0.8452
63 H:	2 H2:			6.803e-003
64 H				24.67
65 H				24.67
ss Hyr	protech Ltd.	HYSYS.Plant v2.2.2 (Build 3806)		Page 10 of 23

_							
1	Dr.			Case Name	e: C:\Documents and S	Settings\mgq\Desktop\NG	NP\FY 09 Report\750 C I
3	HY	INL Calgary,		Unit Set:	NGNP		
4		CANADA		Date/Time:	Wed May 12 11:37:	15 2010	
5 6				Date/ Time.	**************************************	10 20 10	
7		Spreadshe	et: High	Temperatu	re Electroly	sis @TPL1	Inits Set: Electrolysis
9				PARAMET	TERS		
10 11				Exportable V			
12 13	Cell	Visible Nam	-	-		Variable Type	Value
14	H5	H5:	le .	Variable	Description	variable Type	54.46
15	12	12:				Molar Enthalpy	1.887e+005 J/gmole
16	13	13:				Molar Enthalpy	1.887e+005 J/gmole
17	16	16:				Molar Enthalpy	1.887e+005 J/gmole
18	J2	J2:				Entropy	2.321e+008 J/gmole-k
19	J3	J3:				Entropy	2.321e+008 J/gmole-K
20	K2	K2:					0.7607
21	K3	K3:					1.091
22	K6	K6:					
23						Vapour Fraction	1.0067
	K7	K7:					1.007
24 25				User Varia	ables		
26 27				FORMUL	_AS		
28	Cell			Formula			Result
29	B14	=B12*B13					157.2
30	B15	=B11*B14/(4*A6)					437.19 gmole/s
31	B17	@IF(@ABS(D4)<1e-3,K6,K	7)				1.0067
32	B18	=B17+B13*B16					1.2862
33	B19	=-B11*B18*B14/1000					-2.170e+005 kW
34	B20	=B19+D11+D12					2.957e-007 kW
35	D4	=D2-D3					-5.9483e-004 K
36	D6	=(D2+D3)/2					1073.2 K
37	D8	=1/(2*A6*H4*F4)					3.501e-007
38	D9	=-1/(2*A6*H4*F4*D4)					5.887e-004
39	E4	=E3-E2					-0.6000
40	E5	=(E3*@LN(E3)-E3) - (E2*@)LN(F2)-F2)				0.3336
40 41	F4	=F3-F2	, ()				0.6000
42	F5	=(F3*@LN(F3)-F3) - (F2*@	LN(F2)-F2)				-0.6194
42 43	G4	=G3-G2	2.1(1.2) 1.2)				0.4999
44	G5	=(G3*@LN(G3)-G3) - (G2*@	al N(C2)-C2)				-0.8452
45	H2	=G2*A8/A9	BC14(OZ)-OZ)				6.803e-003
46	H3	=G3*A8/A9					24.67
46 47	H4	=H3-H2					24.67
	H5	=(H3*@LN(H3)-H3) - (H2*@	II N(H3/"H3/				54.46
48 49	12	=A1 + A2*D2+ A3*D2*2 + A		I N/D2)			1.887e+005 J/gmole
50	13	=A1 + A2*D2+ A3*D3^2 + A					1.887e+005 J/gmole
54	16	=A1 + A2*D3+ A3*D3*2 + A					1.887e+005 J/gmole
52 53 54	J2	= A1*D2 + A2/2*D2^2 + A3/3		1	2)-0.5)		2.321e+008 J/gmole-k
53	J3	= A1*D3 + A2/2*D3^2 + A3/3					2.321e+008 J/gmole-k
54	K2	=1/(2*A6)*(I2-A7*D2*@LN(E		· AUZ DUZ (WEND	0, 0.0,		0.7607
55	K3						
55 56 57	K6	=1/(2*A6)*(I3-A7*D3*@LN(E		4\\			1.091
50		=D8*(I6*F4*H4 + A7*D6*((E	,				1.0067
58	K7	=D9*(A7/2*(D3^2-D2^2)*((E	3773) R4 + R5/2°F4	4) + F4*H4*(J3-J2)) Spreads	heet		1.007
59		•		<u> </u>			
60	4 -	A	B	С	D Tamananahara i	<u>E</u>	F
61		.382e+005 J/gmole * libbs For			Temperature *	y H2O '	h H2 '
62	2	39.95 J/gmole-K bibbs For		in *	1073.1 K	0.89999	0.10001
63		9e-003 kJ/gmol-K^2 * bibbs For		out *	1073.2 K *	0.30000	0.70000
64	4	-3.532e-008 * n Energy		Delta *	-5.9483e-004 K	-0.6000	0.6000
65	5	-12.85 J/gmole-K * \$ibbs For	mation Energy *	Integration Coeff	(5. 11.10005)	0.3336	-0.6194
66	Hyprote	ech Ltd.		HYSYS.Plant v2.2.2	2 (Build 3806)		Page 11 of 23

66 Hyprotech Ltd. HYSYS.Plant v2.2.2 (Build 3806) Page 11 of 23

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1	2			Case Nam	e: C:\Documente and S	Settings/mag/Deckton/MG	NP\FY 09 Report\750 C H
2			INL			settings/ingq/Desktop///o	NETER OF REPORTING CI
4			Calgary, Alberta CANADA	Unit Set:	NGNP		
5	pr.			Date/Time	: Wed May 12 11:37:	15 2010	
7		Spread	dsheet: High	Temperatu	re Electroly	sis @TPL1	Jnits Set: Electrolysis
8		-					
10	•	4.44		Spreads			
11 12	7	9.649e+004 *	Number (J/Volt-gmole) * Jniversal Gas Constant *	Average *	1073.2 K		
13	8	8.314 J/gmole-K * 5.0000e+006 N/m2	Pressure *	C isothermal *	3.501e-007		
14	9	1.0132e+005 N/m2 *	Standard Pressure *	C average *	5.887e-004		
15	10						
16	11	Number of Cells *	1.073e+006 °	Electrolysis Heating *	2.170e+005 kW		
17	12	Cell Area *	225.0 cm2 *	Electrode Heat *	72.15 kW		
18 19	13 14	ensity (Amperes/cm^2) *	0.6989 ⁻ 157.2				
20	15	Current (Amperes) * Molar Flow of Oxygen *	437.19 gmole/s				
21		Resistance (ohm*cm^2) *	0.4000 *				
22		Nernst Potential (Volts)	1.0067				
23		perating Voltage (Volts) *	1.2862				
24	19	Electrolysis Power *	-2.170e+005 kW				
25	20	Process Heat *	2.957e-007 kW				
26	4	G	H		J	K	
27 28	1	y O2 * 0.00014	y A * 6.803e-003	Delta G * 1.887e+005 J/gmole	Integral Delta G dT * 2.321e+008 J/gmole-K	Nernst Voltage * 0.7607	
29	3	0.50000	24.67	1.887e+005 J/gmole	2.321e+008 J/gmole-K	1.091	
30	4	0.4999	24.67	1.007 C 1000 Orginiolo	2.02 Te · 000 digitiole · K	1.001	
30 31	5	-0.8452	54.46				
32	6			1.887e+005 J/gmole	Isothermal '	1.0067	
33	7				Average *	1.007	
34	8						
35 36	9						
37	10 11						
38	12						
39	13						
40	14						
41	15						
42	16						
43	17						
44	18 19						
45 46	20						
47	LU						
48		Spread	dsheet: Temp	Average A	ASR @TPL1	ι	Jnits Set: Electrolysis
49 50		-		2011150			
51				CONNECT	IONS		
52 53 54				Imported Va	ariables		
53			Ohioat				1/-1
54 55	Ce B1		Object II: Electrolysis Input and C	B5: ASR @ 1100 K	Variable Description		Value 0.2776
56	A3		n: Process In @TPL1	Temperature	(Gillia Gill 2)		1073.1 K
57	E1:		n: Cathode @TPL1	Temperature			1073.1 K
58 59 60 61 62 63 64					Formula Results		
59 60	Се	11	Object		Variable Description		Value
61		m	- ujuut	1	variable Description		value
62							
63							
64							
$\overline{}$	1.			111/01/0 5: : :	2 (2 11 12 22 5		
66	Hyp	rotech Ltd.		HYSYS.Plant v2.2.2	2 (Build 3806)		Page 12 of 23

1	h-		Case Name: C:\Documents and	Settings\mgq\Desktop\N	IGNP\FY 09 Report\750 C I
3		INL Calgary, Alberta	Unit Set: NGNP		<u> </u>
4	-	CANADA	Date/Time: Wed May 12 11:37	:15 2010	
5 6			•		
7		Spreadsheet: Temp	Average ASR @TPL1	(continued	Units Set: Electrolysis
9 10			PARAMETERS		
11			Exportable Variables		
13	Cell	Visible Name	Variable Description	Variable Type	Value
14	A4	A4:	·	Temperature	1073.2 K
15	A5	A5:		Temperature	1073.2 K
16	A6	A6:		Temperature	1073.2 K
17 18	A7 A8	A7:		Temperature	1073.2 K
19	A9	A8: A9:		Temperature Temperature	1073.2 K 1073.2 K
20	A10	A10:		Temperature	1073.2 K
21	A11	A11:		Temperature	1073.2 K
22	A12	A12:		Temperature	1073.2 K
22 23	A13	A13:		Temperature	1073.2 K
24	A14	A14:		Temperature	1073.2 K
25	A15	A15:		Temperature	1073.2 K
26 27	A16	A16:		Temperature	1073.2 K
27	A17	A17:		Temperature	1073.2 K
28 29	A18	A18:		Temperature	1073.2 K
29	A19	A19:		Temperature	1073.2 K
30	A20	A20:			40.00
31	B2	B2: Temp Aver ASR	Temp Aver ASR		0.4000
32	B3	B3:		-	0.4000
33 34	B4	B4:			0.4000
35	B5 B6	B5: B6:			0.4000
36	B7	B7:			0.4000 0.4000
37	B8	B8:			0.4000
38	B9	B9:			0.4000
39	B10	B10:			0.4000
40	B11	B11:			0.4000
41	B12	B12:			0.4000
42	B13	B13:			0.4000
43 44	B14	B14:			0.4000
44	B15	B15:			0.4000
45 46	B16	B16:			0.4000
46	B17	B17:			0.4000
47	B18	B18:			0.4000
48	B19	B19:			0.4000
49 50	B20	B20:		Tomporatura	19.20
5U 51	C1 C2	C1: C2:		Temperature Temperature	1073.2 K 1073.2 K
52	C3	C3:		Temperature	1073.2 K
53	C4	C4:		Temperature	1073.2 K
54	C5	C5:		Temperature	1073.2 K
55	C6	C6:		Temperature	1073.2 K
52 53 54 55 56 57	C7	C7:		Temperature	1073.2 K
57	C8	C8:		Temperature	1073.2 K
58 59 60 61	C9	C9:		Temperature	1073.2 K
59	C10	C10:		Temperature	1073.2 K
60	C11	C11:		Temperature	1073.2 K
61	C12	C12:		Temperature	1073.2 K
62 63 64	C13	C13:		Temperature	1073.2 K
63	C14	C14:		Temperature	1073.2 K
64	C15	C15:		Temperature	1073.2 K
65	C16	C16:	LIVEVE Plant ve a a (Build acce)	Temperature	1073.2 K
66	Hyprote		HYSYS.Plant v2.2.2 (Build 3806)		Page 13 of 23

1	h		Case Name: C:\Documents and	Settings\mgq\Desktop\N	IGNP\FY 09 Report\750 C I
3		INL Calgary, Alberta	Unit Set: NGNP		
4	H	CANADA	Date/Time: Wed May 12 11:37	7:15 2010	
5 6					
7		Spreadsheet: Temp A	verage ASR @TPL1	(continued	Units Set: Electrolysis
9 10			PARAMETERS		
11 12		ı	Exportable Variables		
13	Cell	Visible Name	Variable Description	Variable Type	Value
14	C17	C17:	·	Temperature	1073.2 K
15	C18	C18:		Temperature	1073.2 K
16	C19	C19:		Temperature	1073.2 K
17	D1	D1:			0.4000
18 19	D2	D2:			0.4000
19	D3	D3:			0.4000
20 21	D4	D4:			0.4000
22	D5 D6	D5: D6:			0.4000
22 23	D6	D7:			0.4000 0.4000
24	D8	D8:			0.4000
25	D9	D9:			0.4000
26	D10	D10:			0.4000
26 27	D11	D11:			0.4000
28	D12	D12:			0.4000
28 29	D13	D13:			0.4000
30 31	D14	D14:			0.4000
31	D15	D15:			0.4000
32	D16	D16:			0.4000
33	D17	D17:			0.4000
34	D18	D18:			0.4000
35	D19	D19:			0.4000
36	E1	E1:		Temperature	1073.2 K
37 38	E2	E2:		Temperature	1073.2 K
38	E3	E3:		Temperature	1073.2 K
39 40	E4	E4:		Temperature	1073.2 K
41	E5 E6	E5: E6:		Temperature	1073.2 K 1073.2 K
42	E7	E7:		Temperature Temperature	1073.2 K
42	E8	E8:		Temperature	1073.2 K
43 44	E9	E9:		Temperature	1073.2 K
45	E10	E10:		Temperature	1073.2 K
45 46	E11	E11:		Temperature	1073.2 K
47	E12	E12:		Temperature	1073.2 K
48	E13	E13:		Temperature	1073.2 K
49	E14	E14:		Temperature	1073.2 K
50	F1	F1:			0.4000
51	F2	F2:			0.4000
52 53	F3	F3:			0.4000
53	F4	F4:			0.4000
54	F5	F5:			0.4000
55	F6	F6:			0.4000
56 57	F7 F8	F7: F8:			0.4000 0.4000
58	F9	F9:			0.4000
58 59	F10	F10:			0.4000
60	F11	F11:			0.4000
60 61	F12	F12:			0.4000
62	F13	F13:			0.4000
62 63 64	F14	F14:			0.4000
	F15	F15:			0.4000
65	F16	F16:		Temperature	1.1897e-005 K
66	Hyprote	ch Ltd. HY	SYS.Plant v2.2.2 (Build 3806)		Page 14 of 23

1				
2		INL	se Name: C:\Documents and Settings\mgq\Desktop\NGN	IP\FY 09 Report\750 C I
3	HY	Calgary, Alberta Unit	: Set: NGNP	
5			e/Time: Wed May 12 11:37:15 2010	
6		Occupation to Terror Access	AOD OTDI 4 (
8		Spreadsneet: Temp Average	ge ASR @TPL1 (continuec ਯ	nits Set: Electrolysis
9		Hear	· Variables	
10 11		Osei	variables	
12		FO	RMULAS	
13	Cell	Formul	а	Result
14 15	A4	=A3+F16		1073.2 K
15 16	A5 A6	=A4+F16 =A5+F16		1073.2 K 1073.2 K
17	A7	=A6+F16		1073.2 K
18	A8	=A7+F16		1073.2 K
19	A9	=A8+F16		1073.2 K
20	A10	=A9+F16		1073.2 K
21	A11	=A10+F16		1073.2 K
22	A12	=A11+F16		1073.2 K
23 24	A13	=A12+F16		1073.2 K
25	A14 A15	=A13+F16 =A14+F16		1073.2 K 1073.2 K
26	A16	=A15+F16		1073.2 K
27	A17	=A16+F16		1073.2 K
27 28	A18	=A17+F16		1073.2 K
29 30	A19	=A18+F16		1073.2 K
30	A20	=4*(B4+B6+B8+B10+B12+B14+B16+B18+D1+D3+D5+D7+D9	9+D11+D13+D15+D17+D19+F2+F4+F6+F8+F10+F12+F1	40.00
31	B2	@if(E15==A3,F15,(1/3*F16*(B3+A20+B20+F15))/(E15-A3))		0.4000
32	B3	@EXP(10300/A3)*0.00003973+(B1-0.463)		0.4000
33 34	B4 B5	@EXP(10300/A4)*0.00003973+(B1-0.463) @EXP(10300/A5)*0.00003973+(B1-0.463)		0.4000 0.4000
35	B6	@EXP(10300/A5)*0.00003973+(B1-0.463)		0.4000
35 36	B7	@EXP(10300/A7)*0.00003973+(B1-0.463)		0.4000
37	B8	@EXP(10300/A8)*0.00003973+(B1-0.463)		0.4000
38 39	B9	@EXP(10300/A9)*0.00003973+(B1-0.463)		0.4000
39	B10	@EXP(10300/A10)*0.00003973+(B1-0.463)		0.4000
40 41	B11	@EXP(10300/A11)*0.00003973+(B1-0.463)		0.4000
41	B12	@EXP(10300/A12)*0.00003973+(B1-0.463)		0.4000
42 43	B13 B14	@EXP(10300/A13)*0.00003973+(B1-0.463) @EXP(10300/A14)*0.00003973+(B1-0.463)		0.4000 0.4000
44	B15	@EXP(10300/A15)*0.00003973+(B1-0.463)		0.4000
45	B16	@EXP(10300/A16)*0.00003973+(B1-0.463)		0.4000
46 47	B17	@EXP(10300/A17)*0.00003973+(B1-0.463)		0.4000
	B18	@EXP(10300/A18)*0.00003973+(B1-0.463)		0.4000
48 49	B19	@EXP(10300/A19)*0.00003973+(B1-0.463)		0.4000
49	B20	=2*(B5+B7+B9+B11+B13+B15+B17+B19+D2+D4+D6+D8+D1	10+D12+D14+D16+D18+F1+F3+F5+F7+F9+F11+F13)	19.20
50 51	C1 C2	=A19+F16 =C1+F16		1073.2 K 1073.2 K
52	C3	=C1+F16 =C2+F16		1073.2 K
53	C4	=C3+F16		1073.2 K
54	C5	=C4+F16		1073.2 K
55 56	C6	=C5+F16		1073.2 K
56	C7	=C6+F16		1073.2 K
57 58	C8	=C7+F16		1073.2 K
58 59	C9 C10	=C8+F16 =C9+F16		1073.2 K
60	C10	=C10+F16 =C10+F16		1073.2 K 1073.2 K
61	C12	=C11+F16		1073.2 K
62	C13	=C12+F16		1073.2 K
63	C14	=C13+F16		1073.2 K
64	C15	=C14+F16		1073.2 K
65	C16	=C15+F16		1073.2 K
66	Hyprotect Licensed to:		t v2.2.2 (Build 3806)	Page 15 of 23 * Specified by user.

1	De-		Case Name: C:\Documents and Settings\mgq\Desktop\N	GNP\FY 09 Report\750 C H
3	нү	INL Calgary, Alberta	Unit Set: NGNP	
4 5		CANADA	Date/Time: Wed May 12 11:37:15 2010	
6			•	
7		Spreadsheet: Temp Ave	erage ASR @TPL1 (continued	Units Set: Electrolysis
9 10			FORMULAS	
11	Cell	F	Formula	Result
12	C17	=C16+F16		1073.2 K
13	C18	=C17+F16		1073.2 K
14	C19	=C18+F16		1073.2 K
15	D1	@EXP(10300/C1)*0.00003973+(B1-0.463)		0.4000
16 17	D2 D3	@EXP(10300/C2)*0.00003973+(B1-0.463)		0.4000
18	D3	@EXP(10300/C4)*0.00003973+(B1-0.463)		0.4000 0.4000
19	D5	@EXP(10300/C4)*0.00003973+(B1-0.463) @EXP(10300/C5)*0.00003973+(B1-0.463)		0.4000
20	D6	@EXP(10300/C6)*0.00003973+(B1-0.463)		0.4000
20 21	D7	@EXP(10300/C7)*0.00003973+(B1-0.463)		0.4000
22	D8	@EXP(10300/C8)*0.00003973+(B1-0.463)		0.4000
22 23	D9	@EXP(10300/C9)*0.00003973+(B1-0.463)		0.4000
24	D10	@EXP(10300/C10)*0.00003973+(B1-0.463)		0.4000
25	D11	@EXP(10300/C11)*0.00003973+(B1-0.463)		0.4000
26	D12	@EXP(10300/C12)*0.00003973+(B1-0.463)		0.4000
27	D13	@EXP(10300/C13)*0.00003973+(B1-0.463)		0.4000
28 29	D14	@EXP(10300/C14)*0.00003973+(B1-0.463)		0.4000
29	D15	@EXP(10300/C15)*0.00003973+(B1-0.463)		0.4000
30 31	D16	@EXP(10300/C16)*0.00003973+(B1-0.463)		0.4000
31	D17	@EXP(10300/C17)*0.00003973+(B1-0.463)		0.4000
32 33	D18	@EXP(10300/C18)*0.00003973+(B1-0.463)		0.4000
34	D19 E1	@EXP(10300/C19)*0.00003973+(B1-0.463) =C19+F16		0.4000 1073.2 K
35	E2	=E1+F16		1073.2 K
36	E3	=E2+F16		1073.2 K
37	E4	=E3+F16		1073.2 K
38	E5	=E4+F16		1073.2 K
39 40	E6	=E5+F16		1073.2 K
40	E7	=E6+F16		1073.2 K
41	E8	=E7+F16		1073.2 K
42	E9	=E8+F16		1073.2 K
43	E10	=E9+F16		1073.2 K
44	E11	=E10+F16		1073.2 K
45 46	E12	=E11+F16		1073.2 K
46 47	E13 E14	=E12+F16 =E13+F16		1073.2 K
48	F1	@EXP(10300/E1)*0.00003973+(B1-0.463)		1073.2 K 0.4000
49	F2	@EXP(10300/E1)*0.00003973+(B1-0.463)		0.4000
50	F3	@EXP(10300/E3)*0.00003973+(B1-0.463)		0.4000
51	F4	@EXP(10300/E4)*0.00003973+(B1-0.463)		0.4000
52 53	F5	@EXP(10300/E5)*0.00003973+(B1-0.463)		0.4000
53	F6	@EXP(10300/E6)*0.00003973+(B1-0.463)		0.4000
54	F7	@EXP(10300/E7)*0.00003973+(B1-0.463)		0.4000
55	F8	@EXP(10300/E8)*0.00003973+(B1-0.463)		0.4000
56 57	F9	@EXP(10300/E9)*0.00003973+(B1-0.463)		0.4000
57	F10 F11	@EXP(10300/E10)*0.00003973+(B1-0.463)		0.4000
58 59	F11	@EXP(10300/E11)*0.00003973+(B1-0.463) @EXP(10300/E12)*0.00003973+(B1-0.463)		0.4000 0.4000
60	F13	@EXP(10300/E12)*0.00003973+(B1-0.463) @EXP(10300/E13)*0.00003973+(B1-0.463)		0.4000
60 61	F14	@EXP(10300/E13)*0.00003973+(B1-0.463)		0.4000
62	F15	@EXP(10300/E15)*0.00003973+(B1-0.463)		0.4000
62 63	F16	=(E15-A3)/50		1.1897e-005 K
64 65				
65				
66	Hyprote		S.Plant v2.2.2 (Build 3806)	Page 16 of 23
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1	h					Case Name	e: C	:\Documents and	Settinas\	maa\Desktop\N	GNP\FY 09	Report\750 C I
2			INL							941.0000711		rtoportii oo o i
3		YPROTECH	Calgary, Alb CANADA	erta		Unit Set:		GNP				
5	la.					Date/Time:	V	/ed May 12 11:37	:15 2010	1		
6 7 8		Sprea	dshee	: Te	mp A	verage A	ASR	@TPL1	(cor	ntinuec	Units Set:	Electrolysis
9						Spreadsl	heet					
10 11		Α		3		C		D		E		F
12	1	ASR @ 1100 K *		0.277	6 *	1073.2 K		0.4000		1073.2 K		0.4000
13	2	Temp Average ASR *		0.400	_	1073.2 K		0.4000		1073.2 K		0.4000
14	3	1073.1 K		0.4000	_	1073.2 K		0.4000		1073.2 K		0.4000
15	4	1073.2 K		0.4000		1073.2 K		0.4000		1073.2 K		0.4000
16 17	5	1073.2 K		0.4000		1073.2 K		0.4000		1073.2 K		0.4000
18	6 7	1073.2 K 1073.2 K		0.4000	_	1073.2 K 1073.2 K		0.4000		1073.2 K		0.4000
19	8	1073.2 K		0.4000		1073.2 K		0.4000		1073.2 K		0.4000
20	9	1073.2 K		0.4000		1073.2 K		0.4000		1073.2 K		0.4000
21	10	1073.2 K		0.4000		1073.2 K		0.4000		1073.2 K		0.4000
22	11	1073.2 K		0.4000		1073.2 K		0.4000		1073.2 K		0.4000
23	12	1073.2 K		0.4000		1073.2 K		0.4000		1073.2 K		0.4000
24	13	1073.2 K		0.4000	_	1073.2 K		0.4000		1073.2 K		0.4000
25	14	1073.2 K		0.4000	_	1073.2 K		0.4000		1073.2 K		0.4000
26	15	1073.2 K		0.4000	_	1073.2 K		0.4000		1073.2 K		0.4000
27	16	1073.2 K		0.4000		1073.2 K		0.4000		delta T		1897e-005 K
28	17	1073.2 K		0.4000		1073.2 K		0.4000				
29	18	1073.2 K		0.4000	0	1073.2 K		0.4000				
30	19	1073.2 K		0.4000	0	1073.2 K		0.4000				
31	20	40.00		19.20	0							
32 33 34 35		Conv	ersion	: Ele	ectrol							
36						STOICHION	IETR'	Υ				
37		Componer	nt			Mole Wei	ght			Stoichiom	etric Coeff.	
38	H20							18.015				-1 *
39		rogen						2.016				1*
40 41	Oxy	gen						32.000				0.
42												
43		Balance	Error: 0.00	nn				React	ion Heat	2.410e+005	k.l/kamole	
44 45						BASIS	5					
46		Base Component: H2O			Conversi	on Percent: 100	0.00	•	Rea	action Phase:	VapourPha	se
47 48						PARAMET	ERS					
49 50 51		Workb	ook: C	omb	ined	Cycle (T	PL	2)				
52 53						Material St	reams	5				
54	Nam	e		Steam Ge	nerator Ou	4 @TPL2		To Reheater @T	PL2 To	FW Heater 7 (ат в фт	PL2
55	Vapo	our Fraction			1.0000	1.0	000	1.000	00	1.000	0	1.0000
56		perature	(C)		558.85		1.48	301.4		301.4		558.85
57	Pres		(MPa)		24.000		800 °	4.580	_	4.580		4.1220
58			(gmole/s)		7.0441		441	6.69		0.3522		6.6919
59		s Flow	(kg/s)		126.90		3.90	120.5		6.345		120.56
60		d Volume Flow	(m3/h)		457.8		57.8	434		22.8		434.9
61	Heat	Flow	(kW)	-1.5	96e+006	-1.643e+	006	-1.561e+0	06	-8.215e+00	4	-1.489e+006
62 63 64 65												
66	Нур	rotech Ltd.			HYS	SYS.Plant v2.2.2	(Build	3806)			Pa	age 17 of 23
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2		INL		Case Name:	C:\Documents and Setti	ngs\mgq\Desktop\NGN	P\FY 09 Report\750 C I
3	HYPROTEC	Calgary, A	Alberta	Unit Set:	NGNP		
5	par .			Date/Time:	Wed May 12 11:37:15 2	2010	
6 7	Wor	khooki	Combined	Cycle (TDI	.2) (continu	04)	
8	VVOI	KDOOK.	Combined	Cycle (TFL	. 2) (Continu	eu)	
9 10			Mate	rial Streams (cor	ntinued)		
11	Name		10 @TPL2	11 @TPL2	Steam Generator In (17 @TPL2	13 @TPL2
12	Vapour Fraction		0.0000	0.0000	0.0000	0.0000	1.0000
13	Temperature	(C)	241.24	235.68	254.47	228.56	506.59
14	Pressure	(MPa)	4.4884	27.211	26.667	2.7083	2.9800 *
15 16	Molar Flow	(kgmole/s)	0.35220	7.0441	7.0441	7.0441	6.6919
16	Mass Flow	(kg/s)	6.3450	126.90	126.90 *	126.90	120.56
18	Liquid Volume Flow	(m3/h)	22.89	457.8 -1.888e+006	457.8 -1.875e+006	457.8	434.9 -1.501e+006
19	Heat Flow Name	(kW)	-9.420e+004 14 @TPL2	15 @TPL2	16 @TPL2	-1.892e+006 18 @TPL2	21 @TPL2
20	Vapour Fraction		1.0000	1.0000	0.6590	1.0000	1.0000
21	Temperature	(C)	506.59	506.59	234.20	434.17	434.17
22	Pressure	(MPa)	2.9800	2.9800	2.9800	1.8400 *	1.8400
23	Molar Flow	(kgmole/s)	0.33459	6.3573	0.68680	6.3573	6.0394
24	Mass Flow	(kg/s)	6.0278	114.53	12.373	114.53	108.80
25	Liquid Volume Flow	(m3/h)	21.74	413.1	44.63	413.1	392.5
26	Heat Flow	(kW)	-7.507e+004	-1.426e+006	-1.693e+005	-1.443e+006	-1.371e+006
27	Name		22 @TPL2	20 @TPL2	24 @TPL2	25 @TPL2	26 @TPL2
28	Vapour Fraction		1.0000	0.3947	1.0000	1.0000	1.0000
29	Temperature	(C)	434.17	208.61	349.55	349.55	349.55
30	Pressure	(MPa)	1.8400	1.8400	0.91534	0.91534	0.91534
31	Molar Flow	(kgmole/s)	0.31786	1.0047	6.0394	5.7375	0.30197
32	Mass Flow	(kg/s)	5.7264	18.099	108.80	103.36	5.4400
33	Liquid Volume Flow	(m3/h)	20.66	65.29	392.5	372.8	19.62
34	Heat Flow	(kW)	-7.215e+004	-2.579e+005	-1.389e+006	-1.319e+006	-6.944e+004
35	Name		27 @TPL2	28 @TPL2	35 @TPL2	38 @TPL2	39 @TPL2
36 37	Vapour Fraction	(0)	0.0000	0000.0	0.0000	0.0000	0.0000
	Temperature		176.14	208.27	202.71 2.7636	181.69	147.26
		(C)	2 9200 1				0.91534
	Pressure	(MPa)	2.8200 °	2.9204		1.8032	5 7375
38 39	Pressure Molar Flow	(MPa) (kgmole/s)	7.0441	0.68680	7.0441	1.0047	5.7375 103.36
38 39 40	Pressure Molar Flow Mass Flow	(MPa) (kgmole/s) (kg/s)	7.0441 126.90	0.68680 12.373	7.0441 126.90	1.0047 18.099	103.36
38 39 40 41	Pressure Molar Flow Mass Flow Liquid Volume Flow	(MPa) (kgmole/s) (kg/s) (m3/h)	7.0441 126.90 457.8	0.68680 12.373 44.63	7.0441 126.90 457.8	1.0047 18.099 65.29	103.36 372.8
38 39 40 41 42	Pressure Molar Flow Mass Flow	(MPa) (kgmole/s) (kg/s)	7.0441 126.90 457.8 -1.925e+006	0.68680 12.373 44.63 -1.858e+005	7.0441 126.90 457.8 -1.909e+006	1.0047 18.099 65.29 -2.741e+005	103.36 372.8 -1.582e+006
38 39 40 41	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow	(MPa) (kgmole/s) (kg/s) (m3/h)	7.0441 126.90 457.8	0.68680 12.373 44.63	7.0441 126.90 457.8	1.0047 18.099 65.29	103.36 372.8
38 39 40 41 42 43	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name	(MPa) (kgmole/s) (kg/s) (m3/h)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2	0.68680 12.373 44.63 -1.858e+005 41 @TPL2	7.0441 126.90 457.8 -1.909e+006 43 @TPL2	1.0047 18.099 65.29 -2.741e+005 44 @TPL2	103.36 372.8 -1.582e+006 45 @TPL2
38 39 40 41 42 43 44 45	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction	(MPa) (kgmole/s) (kg/s) (m3/h) (kW)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2	0.68680 12.373 44.63 -1.858e+005 41 @TPL2	7.0441 126.90 457.8 -1.909e+006 43 @TPL2	1.0047 18.099 65.29 -2.741e+005 44 @TPL2	103.36 372.8 -1.582e+006 45 @TPL2 1.0000
38 39 40 41 42 43 44	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature	(MPa) (kgmole/s) (kg/s) (m3/h) (kW)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93
38 39 40 41 42 43 44 45 46 47	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 *	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800
38 39 40 41 42 43 44 45 46 47	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 ° 5.7375 103.36 372.8	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.28687 5.1680 18.64
38 39 40 41 42 43 44 45 46 47 48 49	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8 -1.926e+006	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29 -2.741e+005	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 ° 5.7375 103.36 372.8 -1.333e+006	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2 -1.267e+006	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.28687 5.1680 18.64 -6.667e+004
38 39 40 41 42 43 44 45 46 47 48 49 50	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8 -1.926e+006	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29 -2.741e+005 47 @TPL2	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 ' 5.7375 103.36 372.8 -1.333e+006 48 @TPL2	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2 -1.267e+006 49 @TPL2	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.28687 5.1680 18.64 -6.667e+004 51 @TPL2
38 39 40 41 42 43 44 45 46 47 48 49 50 51	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8 -1.926e+006 46 @TPL2 0.0000	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29 -2.741e+005 47 @TPL2 1.0000	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 ' 5.7375 103.36 372.8 -1.333e+006 48 @TPL2	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2 -1.267e+006 49 @TPL2 0.0000	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.28687 5.1680 18.64 -6.667e+004 51 @TPL2
38 39 40 41 42 43 44 45 46 47 48 49 50 51 52	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8 -1.926e+006 46 @TPL2 0.0000 124.97	0.68680 12.373 44,63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29 -2.741e+005 47 @TPL2 1.0000 209.27	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 ' 5.7375 103.36 372.8 -1.333e+006 48 @TPL2 0.0000 119.41	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2 -1.267e+006 49 @TPL2 0.0000 125.01	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.28687 5.1680 18.64 -6.667e+004 51 @TPL2 1.0000 209.27
38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure	(MPa) (kgmole/s) (kg/s) (m3/h) (kWV) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kWV) (C) (MPa)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8 -1.926e+006 46 @TPL2 0.0000 124.97 0.46844	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29 -2.741e+005 47 @TPL2 1.0000 209.27 0.23300 *	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 * 5.7375 103.36 372.8 -1.333e+006 48 @TPL2 0.0000 119.41 0.93159	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2 -1.267e+006 49 @TPL2 0.0000 125.01 0.23300	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.28687 5.1680 18.64 -6.667e+004 51 @TPL2 1.0000 209.27 0.23300
38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Name Vapour Fraction Temperature Pressure Molar Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8 -1.926e+006 46 @TPL2 0.0000 124.97 0.46844 0.28687	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29 -2.741e+005 47 @TPL2 1.0000 209.27 0.23300 * 5.4506	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 5.7375 103.36 372.8 -1.333e+006 48 @TPL2 0.0000 119.41 0.93159 5.7375	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2 -1.267e+006 49 @TPL2 0.0000 125.01 0.23300 0.28687	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.28687 5.1680 18.64 -6.667e+004 51 @TPL2 1.0000 209.27 0.23300 5.1781
38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 56	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Mass Flow Mass Flow Mass Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8 -1.926e+006 46 @TPL2 0.0000 124.97 0.46844 0.28687 5.1680	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29 -2.741e+005 47 @TPL2 1.0000 209.27 0.23300 * 5.4506 98.193	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 5.7375 103.36 372.8 -1.333e+006 48 @TPL2 0.0000 119.41 0.93159 5.7375 103.36	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2 -1.267e+006 49 @TPL2 0.0000 125.01 0.23300 0.28687 5.1680	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.28687 5.1680 18.64 -6.667e+004 51 @TPL2 1.0000 209.27 0.23300 5.1781 93.283
38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Name Vapour Fraction Temperature Pressure Molar Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8 -1.926e+006 46 @TPL2 0.0000 124.97 0.46844 0.28687	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29 -2.741e+005 47 @TPL2 1.0000 209.27 0.23300 * 5.4506	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 5.7375 103.36 372.8 -1.333e+006 48 @TPL2 0.0000 119.41 0.93159 5.7375	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2 -1.267e+006 49 @TPL2 0.0000 125.01 0.23300 0.28687	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.28687 5.1680 18.64 -6.667e+004 51 @TPL2 1.0000 209.27 0.23300 5.1781
38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kgmole/s) (kgmole/s)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8 -1.926e+006 46 @TPL2 0.0000 124.97 0.46844 0.28687 5.1680 18.64	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29 -2.741e+005 47 @TPL2 1.0000 209.27 0.23300 5.4506 98.193 354.2	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 5.7375 103.36 372.8 -1.333e+006 48 @TPL2 0.0000 119.41 0.93159 5.7375 103.36 372.8 372.8	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2 -1.267e+006 49 @TPL2 0.0000 125.01 0.23300 0.28687 5.1680 18.64	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.26687 5.1680 18.64 -6.667e+004 51 @TPL2 1.0000 209.27 0.23300 5.1781 93.283 336.5
38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56	Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow Heat Flow Name Vapour Fraction Temperature Pressure Molar Flow Mass Flow Liquid Volume Flow	(MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kW) (C) (MPa) (kgmole/s) (kg/s) (m3/h) (kgmole/s) (kgmole/s)	7.0441 126.90 457.8 -1.925e+006 40 @TPL2 0.0000 175.74 0.91534 7.0441 126.90 457.8 -1.926e+006 46 @TPL2 0.0000 124.97 0.46844 0.28687 5.1680 18.64 -7.962e+004	0.68680 12.373 44.63 -1.858e+005 41 @TPL2 0.0129 176.21 0.91534 1.0047 18.099 65.29 -2.741e+005 47 @TPL2 1.0000 209.27 0.23300 5.4506 98.193 354.2	7.0441 126.90 457.8 -1.909e+006 43 @TPL2 1.0000 278.93 0.47800 ' 5.7375 103.36 372.8 -1.333e+006 48 @TPL2 0.0000 119.41 0.93159 5.7375 103.36 372.8 -1.595e+006	1.0047 18.099 65.29 -2.741e+005 44 @TPL2 1.0000 278.93 0.47800 5.4506 98.193 354.2 -1.267e+006 49 @TPL2 0.0000 125.01 0.23300 0.28687 5.1680 18.64	103.36 372.8 -1.582e+006 45 @TPL2 1.0000 278.93 0.47800 0.26687 5.1680 18.64 -6.667e+004 51 @TPL2 1.0000 209.27 0.23300 5.1781 93.283 336.5

2		INL		Case Name:	C:\Documents and Setti	ings\mgq\Desktop\NGN	P\FY 09 Report\750 C I			
3	HYPROTEC	Colgony	Alberta	Unit Set:	NGNP					
5	Barrier St.	CANADA		Date/Time:	Date/Time: Wed May 12 11:37:15 2010					
6					a					
7	Wor	kbook:	Combined	Cycle (TPL	.2) (continu	ied)				
9			Mata	rial Straama (aa.	-tim					
10				rial Streams (co						
11 12	Name Vancus Frantism		52 @TPL2 1.0000	53 @TPL2 1.0000	54 @TPL2 1.0000	55 @TPL2 1.0000	56 @TPL2 0.0000			
13	Vapour Fraction Temperature	(C)	209.27	129.77	1.0000	129.77	96.628			
14	Pressure	(MPa)	0.23300	9.0000e-002 *	9.0000e-002	9.0000e-002	0.22834			
15	Molar Flow	(kgmole/s)	0.27253	5.1781	4.7172	0.46085	0.55940			
16	Mass Flow	(kg/s)	4.9096	93.283	84.981	8.3022	10.078			
17	Liquid Volume Flow	(m3/h)	17.71	336.5	306.5	29.95	36.35			
18	Heat Flow	(kW)	-6.399e+004	-1.230e+006	-1.120e+006	-1.095e+005	-1.565e+005			
19	Name		57 @TPL2	60 @TPL2	62 @TPL2	64 @TPL2	74 @TPL2			
20	Vapour Fraction		0.0000	0.0000	0.0000	0.9411	0.4642			
21	Temperature	(C)	91.072	43.698	38.142	38.958	96.678			
22	Pressure	(MPa)	0.95060	8.8200e-002	0.97000 *	6.8948e-003 *	9.0000e-002			
23 24	Molar Flow	(kgmole/s)	5.7375	1.0202	5.7375	4.7172	1.0202			
24 25	Mass Flow	(kg/s)	103.36	18.380	103.36	84.981	18.380 66.30			
26	Liquid Volume Flow Heat Flow	(m3/h)	372.8 -1.608e+006	66.30 -2.897e+005	372.8 -1.632e+006	306.5 -1.147e+006	-2.660e+005			
27	Name	(kW)	78 @TPL2	34 @TPL2	23 @TPL2	36 @TPL2	37 @TPL2			
28	Vapour Fraction		0.0000	0.0203	0.0000	0.5233	0.0000			
_	Temperature	(C)	36.817	234.20	208.33	125.07	96.654			
29 30	Pressure	(MPa)	6.7569e-003	2.9800	1.8400	0.23300	9.0000e-002			
31	Molar Flow	(kgmole/s)	4.7172	0.35220	0.68680	0.55940	0.55940			
32	Mass Flow	(kg/s)	84.981	6.3450	12.373	10.078	10.078			
33	Liquid Volume Flow	(m3/h)	306.5	22.89	44.63	36.35	36.35			
34	Heat Flow	(kW)	-1.342e+006	-9.420e+004	-1.858e+005	-1.436e+005	-1.565e+005			
35	Name		58 @TPL2	59 @TPL2	63 @TPL2	79 @TPL2	81 @TPL2			
36	Vapour Fraction		0.0000	0.0091	1.0000	1.0000	1.0000			
37 38	Temperature	(C)	38.042	38.582	583.85	583.85	299.15			
39	Pressure Molar Flow	(MPa) (kgmole/s)	6.7569e-003 5.7375	6.7569e-003 1.0202	6.8600 47.247	6.8600 13.489	6.7200 47.247			
40	Mass Flow	(kg/s)	103.36	18.380	189.13	53.997	189.13			
41	Liquid Volume Flow	(m3/h)	372.8	66.30	5488	1567	5488			
42	Heat Flow	(kW)	-1.632e+006	-2.897e+005	5.522e+005	1.576e+005	2.726e+005			
43	Name	,,,,,	82 @TPL2	6 @TPL2	7 @TPL2	29 @TPL2	32 @TPL2			
44	Vapour Fraction		1.0000	1.0000	1.0000	1.0000	1.0000			
45	Temperature	(C)	326.48	750.00	750.00	583.85	725.00 °			
46	Pressure	(MPa)	6.7200	7.0000	7.0000	6.8600	4.2630			
47	Molar Flow	(kgmole/s)	13.489	30.368	30.368	60.736	30.381			
48 49	Mass Flow	(kg/s)	53.997	121.56	121.56	243.13	121.61			
49	Liquid Volume Flow	(m3/h)	1567	3527	3527	7055	3529			
5U 51	Heat Flow Name	(kW)	8.549e+004 33 @TPL2	4.598e+005 42 @TPL2	4.598e+005 50 @TPL2	7.098e+005 61 @TPL2	4.435e+005 65 @TPL2			
52	Vapour Fraction		1.0000	1.0000	1.0000	1.0000	1.0000			
53	Temperature	(C)	573.00	143.02	114.09	35.000	117.58			
54	Pressure	(MPa)	2.6800 *	2.6264	4.3300 *	4.2434	7.2886 *			
55	Molar Flow	(kgmole/s)	30.381	30.381	30.381	30.381	30.381			
56	Mass Flow	(kg/s)	121.61	121.61	121.61	121.61	121.61			
50	Liquid Volume Flow	(m3/h)	3529	3529	3529	3529	3529			
57	· ·			7.543e+004	5.772e+004	7755	6.090e+004			
57 58	Heat Flow	(kW)	3.470e+005	7.5436+004						
57 58	· ·	(kW)	3.470e+005	7.34364004						
57	· ·	(kW)		SYS.Plant v2.2.2 (Buil			Page 19 of 23			

2	INL		Case Name:	C:\Documents and Settin	ngs\mgq\Desktop\NGNF	P\FY 09 Report\750 C H
3	Calgary, A	Alberta	Unit Set:	NGNP		
5	CANADA		Date/Time:	Wed May 12 11:37:15 2	2010	
6	Markhaak	Combined	Cycle (TDI	2) (continu	od)	
8	Workbook:	Combined	Cycle (TPL	.2) (continu	eu)	
9 10		Mate	rial Streams (coi	ntinued)		
11	Name	66 @TPL2	67 @TPL2	12 @TPL2	9 @TPL2	19 @TPL2
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
13	Temperature (C)	35.000 *	573.06	594.65	725.00 *	569.65
14	Pressure (MPa)	2.5739	6.8600	6.8600	7.0000	4.3500 *
15	Molar Flow (kgmole/s)	30.381	30.368	30.368	30.381	30.381
16	Mass Flow (kg/s)	121.61	121.56	121.56	121.61	121.61
17	Liquid Volume Flow (m3/h)	3529	3527	3527	3529	3529
18 19	Heat Flow (kW)	7190	3.481e+005	3.617e+005	4.442e+005	3.454e+005
20	Name Vapour Fraction	30 @TPL2 1.0000	In @TPL2 1.0000	Out @TPL2 1.0000		
21	Temperature (C)	548.00	750.00	305.22		
22	Pressure (MPa)	7.1429	7.0000	6.7200		
23	Molar Flow (kgmole/s)	30.381	60.736	60.736		
24	Mass Flow (kg/s)	121.61	243.13	243.13		
25	Liquid Volume Flow (m3/h)	3529	7055	7055		
26	Heat Flow (kW)	3.325e+005	9.196e+005	3.581e+005		
27	(,		Compositions			
28						
29	Name	Steam Generator Out		To Reheater @TPL2	To FW Heater 7 @TF	
30	Comp Mole Frac (H2O)	1.00000 *	1.00000	1.00000	1.00000	1.00000
31 32	Comp Mole Frac (Helium)	0.00000 *	0.00000	0.00000	0.00000	0.00000
33	Name	10 @TPL2	11 @TPL2	Steam Generator In (17 @TPL2	13 @TPL2
34	Comp Mole Frac (H2O) Comp Mole Frac (Helium)	1.00000 0.00000	1.00000 0.00000	1.00000 0.00000	1.00000 0.00000	1.00000 0.00000
35	Name	14 @TPL2	15 @TPL2	16 @TPL2	18 @TPL2	21 @TPL2
36	Comp Mole Frac (H2O)	1.00000	1.00000	1.00000	1.00000	1.00000
37	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000
38	Name	22 @TPL2	20 @TPL2	24 @TPL2	25 @TPL2	26 @TPL2
39	Comp Mole Frac (H2O)	1.00000	1.00000	1.00000	1.00000	1.00000
40	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000
41	Name	27 @TPL2	28 @TPL2	35 @TPL2	38 @TPL2	39 @TPL2
42	Comp Mole Frac (H2O)	1.00000	1.00000	1.00000	1.00000	1.00000
43	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000
44	Name	40 @TPL2	41 @TPL2	43 @TPL2	44 @TPL2	45 @TPL2
45	Comp Mole Frac (H2O)	1.00000	1.00000	1.00000	1.00000	1.00000
46	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000
47	Name	46 @TPL2	47 @TPL2	48 @TPL2	49 @TPL2	51 @TPL2
48 49	Comp Mole Frac (H2O)	1.00000	1.00000	1.00000	1.00000	1.00000
49 50	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000
50	Name Comp Mole Frac (H2O)	52 @TPL2 1.00000	53 @TPL2 1.00000	54 @TPL2 1.00000	55 @TPL2 1.00000	56 @TPL2 1.00000
52	Comp Mole Frac (H2O) Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000
53	Name	57 @TPL2	60 @TPL2	62 @TPL2	64 @TPL2	74 @TPL2
54	Comp Mole Frac (H2O)	1.00000	1.00000	1.00000	1.00000	1.00000
55	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000
56	Name	78 @TPL2	34 @TPL2	23 @TPL2	36 @TPL2	37 @TPL2
57	Comp Mole Frac (H2O)	1.00000	1.00000	1.00000	1.00000	1.00000
58	Comp Mole Frac (Helium)	0.00000	0.00000	0.00000	0.00000	0.00000
59	Name	58 @TPL2	59 @TPL2	63 @TPL2	79 @TPL2	81 @TPL2
60	Comp Mole Frac (H2O)	1.00000	1.00000	0.00000	0.00000	0.00000
_	Comp Mole Frac (Helium)	0.00000	0.00000	1.00000	1.00000	1.00000
61	Comp more i rao (i remain)			7 @TPL2	29 @TPL2	32 @TPL2
61 62	Name	82 @TPL2	6 @TPL2			
61 62 63	Name Comp Mole Frac (H2O)	0.00000	0.00000	0.00000	0.00000	0.00000
61 62 63 64	Name					
61 62 63 64 65	Name Comp Mole Frac (H2O)	0.00000 1.00000	0.00000	0.00000 1.00000	0.00000	0.00000

1	h.				Case Name: (2:\Documents and Setti	nae/maa/l	Deckton/NGNE	NEV 00 Report\750 C
2	INL Calgary, Alberta CANADA				Case Name: C:\Documents and Settings\mgq\Desktop\NGNP\FY 09 Report\750 C H				
3					Unit Set: NGNP				
5					Date/Time: V	Date/Time: Wed May 12 11:37:15 2010			
6 7 8	Workb	ook:	Combine	d C	ycle (TPL	2) (continu	ed)		
9	Compositions (continued)								
10 11	Name		33 @TPL2		42 @TPL2	50 @TPL2	61 @TF	PL2	65 @TPL2
12	Comp Mole Frac (H2O)		0.000		0.00000	0.00000	71 911	0.00000	0.00000
13	Comp Mole Frac (Helium) 1.		1.000	1.00000		1.00000	1.00000		1.00000
14			66 @TPL2			12 @TPL2	9 @TPL2		19 @TPL2
15	Comp Mole Frac (H2O)		0.00000		0.00000	0.00000		0.00000 *	0.00000
16 17	Comp Mole Frac (Helium) Name		1.00000		1.00000	1.00000 Out @TPL2		1.00000 *	1.00000
18	Comp Mole Frac (H2O)		30 @TPL2 0.000		0.00000	0.00000			
19	Comp Mole Frac (Helium)		1.000		1.00000	1.00000			
20 21	Energy Streams								
22	Name		HP Trbn Pwr @T	PL2 I	T Trbn Stg 1 Pwr @1	ITTrbn Stg 2 Pwr @T	LP Trb	Stg 1 Pwr @T	Bstr Pmp Pwr @TPL:
23	Heat Flow	(kW)	4.716e+0	_	1.268e+004	1.652e+004		.794e+004	366.2
24	Name		LP Trbn Stg 2 Pv	/r@ L	LP Trbn Stg 3 Pwr @	LP Trbn Stg 4 Pwr @	LP Trg	Stg 5 Pwr @T	Cond Q @TPL2
25	Heat Flow	(kW)	1.410e+0	04	1.307e+004	1.401e+004		2.649e+004	1.952e+005
26	Name		BF Pmp Pwr @T	PL2 (Cnd Pmp Pwr @TPL1	LP Trb Pwr @TPL2		Pwr @TPL2	LP Cmp Pwr @TPL2
27	Heat Flow	(kW)	49:	_	133.1	9.644e+004		9.883e+004	5.053e+004
28	Name		Intercooler Q @T	-	HP Cmp Pwr @TPL2			Power Out @	
29	Heat Flow	(kW)	4.997e+0	04	5.315e+004	6.824e+004	2	2.467e+005	
30	Unit Ops								
32	Operation Name	Ope	eration Type		Feeds	Products		Ignored	Calc. Level
33	High Pressure Turbine @TPI	Expande	r	Stea	m Generator Out @T	PL 4@TPL2		No	500.0
34	Tilgit Fressule Turbine @1F1	LAPATIGE	•			HP Trbn Pwr @TPL2		140	300.0
35 36	Intermdiate Pressure Turbine	Expander		8 @TPL2		13 @TPL2 IT Trbn Stg 1 Pwr @TPL2		No	500.0 *
37	Intermediatte Pressure Turbi	Expander		15 @TPL2		18 @TPL2		No	500.0 *
38 39		Expander		21 @	### ITTrbn Stg 2 Pwr @ ###################################		2TPL2		
40	Low Pressure Turbine Stage	Expander				LP Trb Stg 1 Pwr @TPL2		No	500.0 *
41 42	Low Pressure Turbine Stage	age Expander		25 @	TPL2	43 @TPL2 LP Trbn Stg 2 Pwr @Ti		No	500.0 *
43	Low Pressure Turbine Stage	e Stage Expander		44 @	TPL2	47 @TPL2		No	500.0 *
44 45	-			51 @	ATPL 2	LP Trbn Stg 3 Pwr	@TPL2		
46	Low Pressure Turbine Stage Expander		o i @	TPL2	53 @TPL2 LP Trbn Stg 4 Pwr @TPL2		No	500.0 *	
47 48	Low Pressure Turbine Stage Expander		54 @TPL2		64 @TPL2 LP Trg Stg 5 Pwr @TPL2		No	500.0 *	
49	HP Turbine @TPL2 Expander		9 @TPL2		19 @TPL2		No	500.0 *	
50 51	-			32 @	TPL2	HP Trb Pwr @TPL2 33 @TPL2			
52	LP Turbine @TPL2 Expander				LP Trb Pwr @TPL2		No	500.0 *	
53 54	4 @TPL2 Tee		4 @TPL2		To Reheater @TPL2 To FW Heater 7 @TPL2		No	500.0 *	
55 56	T6 @TPL2	L2 Tee		13 @TPL2		14 @TPL2 15 @TPL2		No	500.0 *
57 58	T7 @TPL2 Tee		18 @TPL2		21 @TPL2 22 @TPL2		No	500.0 *	
59	T8 @TPL2 Tee		24 @TPL2		25 @TPL2		No	500.0 *	
60 61			43 @TPL2		26 @TPL2 44 @TPL2				
62	T9 @TPL2 Tee				45 @TPL2	No		500.0 *	
63 64			47 @	TPL2	51 @TPL2 52 @TPL2		No	500.0 *	
65	T11 @TPL2	Tee		53 @	TPL2	54 @TPL2		No	500.0 *
66	Hyprotech Ltd.				S.Plant v2.2.2 (Build				Page 21 of 23
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1	<u></u>		Case Name: C:	\Documents and Settings\mag\D	eskton\NGNP\F	V 09 Report\750 C			
2		INL							
3	HYPROTECH	Calgary, Alberta CANADA	Unit Set: NO	Unit Set: NGNP					
5	Barre S. Commission of the Com	CANADA	Date/Time: W	Date/Time: Wed May 12 11:37:15 2010					
6	6								
8	Workbook: Combined Cycle (TPL2) (continued)								
9	Unit Ops (continued)								
11	Operation Name	Operation Type	Feeds	Products	Ignored	Calc. Level			
12	T11 @TPL2	Tee		55 @TPL2	No	500.0 °			
13	T13 @TPL2	Tee	29 @TPL2	79 @TPL2	No	500.0 *			
14 15	_		In @TPL2	63 @TPL2 6 @TPL2					
16	TEE-100 @TPL2	Tee	III W I I L L	7 @TPL2	No	500.0 *			
17	Feedwater Heater 7 @TPL2	Heat Exchanger	11 @TPL2	Steam Generator In @TPL2	No	500.0 *			
18	1 0000000000000000000000000000000000000	Trock Exercising of	To FW Heater 7 @TPL2	10 @TPL2					
19 20	Feedwater Heater 6 @TPL2	Heat Exchanger	35 @TPL2 16 @TPL2			500.0 *			
21			27 @TPL2	35 @TPL2					
22	Feedwater Heater 5 @TPL2	Heat Exchanger	20 @TPL2	38 @TPL2	No	500.0 *			
23	Feedwater Heater 3 @TPL2	Heat Exchanger	48 @TPL2	39 @TPL2	No	500.0 *			
24			45 @TPL2	46 @TPL2					
25 26	Feedwater Heater 2 @TPL2	Heat Exchanger	57 @TPL2 36 @TPL2	48 @TPL2 56 @TPL2	No	500.0° 500.0° 500.0°			
27			62 @TPL2	57 @TPL2					
28	Feedwater Heater 1 @TPL2	Heat Exchanger	74 @TPL2	60 @TPL2	No				
29 30	IHX 1 @TPL2	Heat Exchanger	30 @TPL2	9 @TPL2	No				
		Trock Exercising of	6 @TPL2	67 @TPL2	140				
31 32	IHX 2 @TPL2	Heat Exchanger	19 @TPL2 7 @TPL2	32 @TPL2 12 @TPL2	No				
33			17 @TPL2	11 @TPL2		500 5			
34	Boiler Feed Pump @TPL2	Pump	BF Pmp Pwr @TPL2	11 @11 22	No	500.0			
35	Booster Pump @TPL2	Pump	40 @TPL2	27 @TPL2	No	500.0 *			
36	500000 1 unp @ 11 22		Bstr Pmp Pwr @TPL2	00 OTDI 0					
37 38	Condensate Pump @TPL2	Pump	58 @TPL2 Cnd Pmp Pwr @TPL2	62 @TPL2	No	500.0 *			
39			34 @TPL2	16 @TPL2					
40	M3 @TPL2	Mixer	14 @TPL2		No	500.0 *			
41	M4 @TPL2	Mixer	22 @TPL2	20 @TPL2	No	500.0 *			
42 43			23 @TPL2	40 OTDI 0					
	Deaerating Heater @TPL2	Mixer	39 @TPL2 41 @TPL2	40 @TPL2	No	500.0 °			
44 45	Deacrating reater (@TF LZ	IVIIACI	26 @TPL2		140				
46 47	M44 @TDL2	Mixer	55 @TPL2	74 @TPL2	No				
=	M11 @TPL2	IVIIXEF	37 @TPL2		INO	500.0			
48 49	M13 @TPL2	Mixer	52 @TPL2	36 @TPL2		500.0 *			
49 50	-		49 @TPL2 59 @TPL2	58 @TPL2					
51	M14 @TPL2	Mixer	78 @TPL2	30 @ 11 22	No	500.0 *			
52 53	M7 @TPL2	Mixer	81 @TPL2	Out @TPL2	No	500.0 *			
53	WIT WELLE	MING	82 @TPL2		140	300.0			
54 55	MIX-100 @TPL2	Mixer	67 @TPL2 12 @TPL2	29 @TPL2	No	500.0 *			
56	VLV 8 @TPL2	Valve	38 @TPL2	41 @TPL2	No	500.0 *			
57	VLV 10 @TPL2	Valve	46 @TPL2	49 @TPL2	No	500.0 °			
58	VLV 11 @TPL2	Valve	56 @TPL2	37 @TPL2	No	500.0 *			
59	VLV 18 @TPL2	Valve	10 @TPL2	34 @TPL2	No	500.0 *			
60 61	VLV 17 @TPL2 VLV 13 @TPL2	Valve Valve	28 @TPL2 60 @TPL2	23 @TPL2 59 @TPL2	No No	500.0 * 500.0 *			
62			64 @TPL2	78 @TPL2		500.0 *			
63	Condenser @TPL2	Cooler		Cond Q @TPL2	No				
64	Intercooler @TPL2	Cooler	50 @TPL2	61 @TPL2	No	500.0 *			
65			INOVO Planti O O O (P. 11)	Intercooler Q @TPL2					
Hysys.Plant v2.2.2 (Build 3806)						Page 22 of 23			

1	1 Case Name: CiDeauments and Cettings large Decided N/CNDIEV 00 Paget 1750 CI								
2		INL Colgany Alberta	Case Name: C:\Documents and Settings\mgq\Desktop\NGNP\FY 09 Report\750 C H						
3 4 5	HYPROTECH	Calgary, Alberta CANADA	Unit Set: NGNP						
			Date/Time: Wed May 12 11:37:15 2010						
6 7 8	Workbook: Combined Cycle (TPL2) (continued)								
9 10	Unit Ops (continued)								
11	Operation Name	Operation Type	Feeds	Products	Ignored	Calc. Level			
12 13	Cooler @TPL2	Cooler	42 @TPL2	66 @TPL2 Cooler Q @TPL2	No	500.0 *			
14 15	Steam Generator @TPL2	LNG	63 @TPL2 Steam Generator In @TPL2	81 @TPL2 Steam Generator Out @TPL	No	500.0 *			
16 17	Reheater @TPL2	LNG	79 @TPL2 To Reheater @TPL2	82 @TPL2 8 @TPL2	No	500.0 *			
18 19	Brayton Recup @TPL2	LNG	65 @TPL2 33 @TPL2	30 @TPL2 42 @TPL2	No	500.0 *			
20	LP Compressor @TPL2	Compressor	66 @TPL2	50 @TPL2	No	500.0 *			
21 22 23	HP Compressor @TPL2	Compressor	LP Cmp Pwr @TPL2 61 @TPL2	65 @TPL2	No	500.0 *			
23 24	ADJ-1 @TPL2	Adjust	HP Cmp Pwr @TPL2		No	3500 *			
25	ADJ-2 @TPL2	Adjust			Yes	3500 *			
26	ADJ-3 @TPL2	Adjust			No	3500 *			
27	SET-1 @TPL2	Set			No	500.0 *			
28	SET-2 @TPL2	Set			No	500.0 °			
29	Efficiency Calculations @TP	Spreadsheet			No	500.0 *			
30	Pressure Drops @TPL2	Spreadsheet			No	500.0 *			
31 32	Pressure Drops Brayton @T Brayton Efficiency @TPL2	Spreadsheet Spreadsheet			No No	500.0 °			
36 37 38 39 40 41 42 43 44 45 64 47 48 49 50 51 52 53 54 55 56 57 58 60 61 62 63 64 64 65									
62 63									
65									
66	Hyprotech Ltd.		HYSYS.Plant v2.2.2 (Build 3	806)		Page 23 of 23			

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